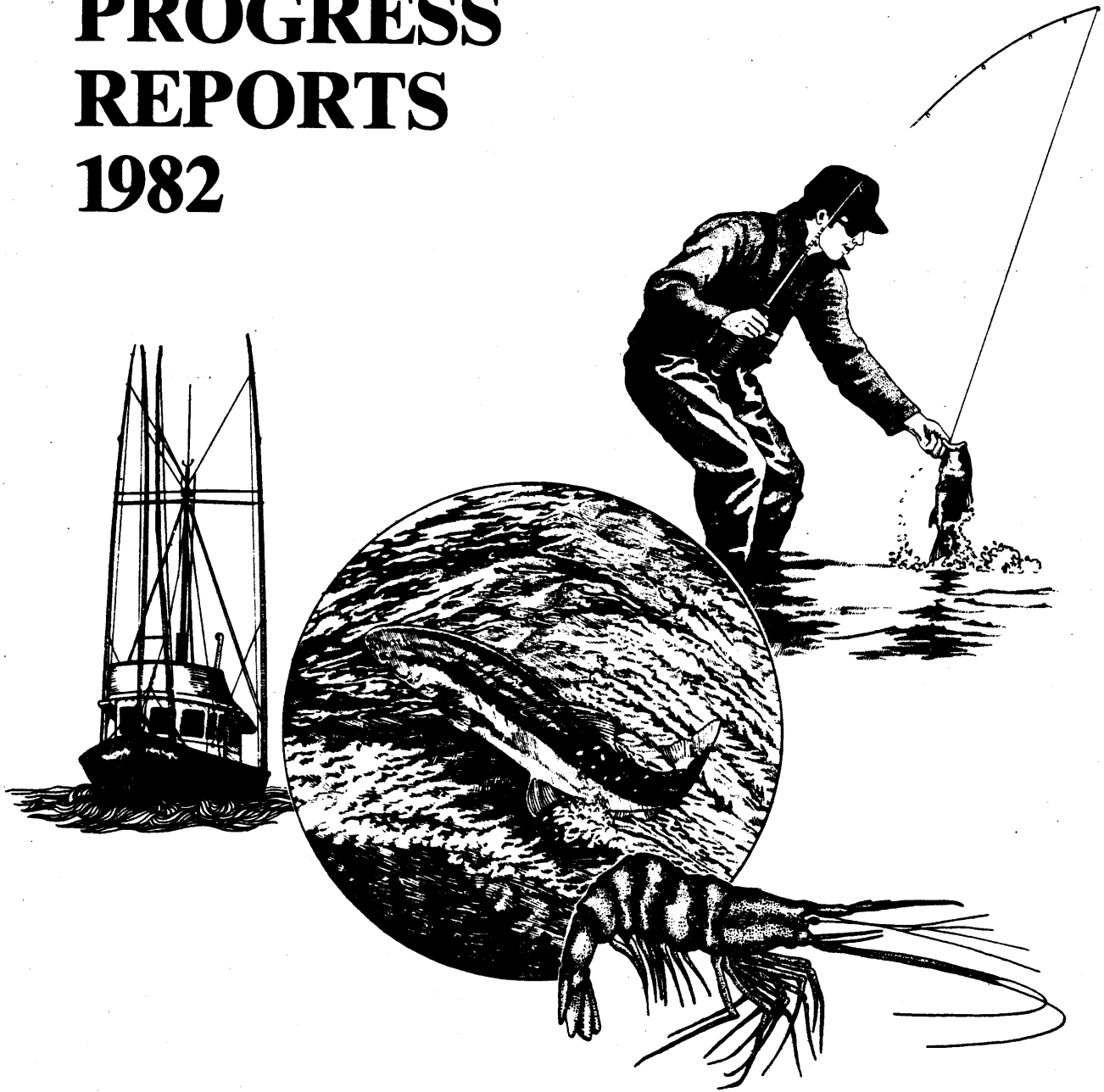


PROGRESS REPORTS 1982



FISH DIVISION Oregon Department of Fish and Wildlife

Indexing of Juvenile Salmonids Migrating Past
The Dalles Dam, 1982

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The Dalles Dam, 1982.

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CONTENTS

	<u>Page</u>
ABSTRACT	1
INTRODUCTION	1
Background	1
Goals and Objectives	3
METHODS	3
Sluiceway and Site Description	3
Sluiceway Operation	3
Description of Sluiceway Fish Trap	6
Objective 1.0. Recover fish marked and released by NMFS to estimate travel time and survival of juvenile salmonids from selected points between McNary and The Dalles dams.....	8
Objective 2.0. Determine the bypass efficiency for juvenile salmonids through The Dalles Dam sluiceway...	8
Objective 3.0. Determine the effects of variation in season, river temperature, turbidity, powerhouse loading, nitrogen saturation, spill, fish size and fish species on the proportion of emigrants captured in the fish trap.....	9
Objective 4.0. Determine the rate of descaling and delayed mortality caused to fish captured by the fish trap.....	10
RESULTS AND DISCUSSION.....	11
Objective 1.0. Recover fish marked and released by NMFS to estimate travel time and survival of juvenile salmonids from selected points between McNary and The Dalles dams.....	11
Objective 2.0. Determine the bypass efficiency for juvenile salmonids through The Dalles Dam sluiceway...	17
Objective 3.0. Determine the effects of variation in season, river temperature, turbidity, powerhouse loading, nitrogen saturation, spill, fish size and fish species on the proportion of emigrants captured in the fish trap.....	28
Objective 4.0. Determine the rate of descaling and delayed mortality caused to fish captured by the fish trap.....	28
CONCLUSIONS.....	35
RECOMMENDATIONS.....	35
ACKNOWLEDGEMENTS.....	36
REFERENCES.....	37
APPENDICES.....	38

LIST OF TABLES

<u>Number</u>		<u>Page</u>
1.	Recapture rate of hatchery coho salmon released into The Dalles Dam sluiceway before modification of the trap entrance, 1982.....	23
2.	Recapture rate of hatchery coho salmon released into The Dalles Dam sluiceway after modification of the trap entrance, 1982.....	24
3.	Capture efficiency of the sluiceway fish trap with respect to fish passing The Dalles Dam powerhouse and efficiency of The Dalles Dam sluiceway for bypassing juvenile salmonids.....	26
4.	Subyearling chinook and yearling coho salmon descaling rates from releases into the sluiceway fish trap.....	32
5.	Subyearling chinook and yearling coho salmon mortality rates from releases into the sluiceway fish trap.....	34

LIST OF FIGURES

<u>Number</u>		<u>Page</u>
1.	Location of dams affecting anadromous fish passage on the main stem Columbia and Snake rivers.....	2
2.	Plan view of The Dalles Dam, Columbia River.....	4
3.	Cross section of a Columbia River dam with a sluiceway.....	5
4.	Side view of the fish trap and work platform.....	7
5.	Catch rate of steelhead trout (ST) and mean rate of spilling by week at The Dalles Dam from April 26 through July 4, 1982..	12
6.	Catch rate of coho salmon (CO) and mean rate of spilling by week at The Dalles Dam from April 26 through July 4, 1982.....	13
7.	Catch rate of sockeye salmon (SO) and mean rate of spilling by week at The Dalles Dam from April 26 through July 4, 1982..	14
8.	Catch rate of yearling (spring) chinook salmon (CHS) and mean rate of spilling by week at The Dalles Dam from April 26 through July 4, 1982.....	15
9.	Catch rate of subyearling (fall) chinook salmon (CHF) and mean rate of spilling by week at The Dalles Dam from April 26 through July 4, 1982.....	16
10.	Percent of total steelhead trout catch from April 26 through July 4, 1982, at The Dalles Dam occurring at each hour of sluiceway fish trap operation.....	18
11.	Percent of total coho salmon catch from April 26 through July 4, 1982 at The Dalles Dam occurring at each hour of sluiceway fish trap operation.....	19
12.	Percent of total sockeye salmon catch from April 26 through July 4, 1982 at The Dalles Dam occurring at each hour of sluiceway fish trap operation.....	20
13.	Percent of total yearling (spring) chinook salmon catch from April 26 through July 4, 1982 at The Dalles Dam occurring at each hour of sluiceway fish trap operation.....	21
14.	Percent of total subyearling (fall) chinook salmon catch from April 26 through July 4, 1982 at The Dalles Dam occurring at each hour of sluiceway fish trap operation.....	22
15.	Relationship between mean percentage of total river flow passing The Dalles Dam as spill and sluiceway fish bypass efficiency.....	27

LIST OF FIGURES (Cont'd)

<u>Number</u>	<u>Page</u>
16. Relationship between percentage of total river flow passing The Dalles Dam as spill and spillway fish bypass efficiency	29
17. Relationship between percentage of total river flow passing The Dalles Dam as spill and percentage of total outmigrating juvenile salmonids passing the project which pass either through spill or through the sluiceway (fish bypass efficiency) when both are operated.....	30

LIST OF APPENDICES

<u>Number</u>	<u>Page</u>
1. Releases of branded fish into The Dalles Dam pool	39
2. Mean values of environmental parameters which occurred during recovery with The Dalles Dam sluiceway fish trap of yearling (spring) chinook salmon and steelhead trout released below John Day Dam May 6-22, 1982.....	40
3. Recoveries of marked yearling (spring) chinook salmon at The Dalles Dam, 1982.....	41
4. Recoveries of marked yearling steelhead trout at The Dalles Dam, 1982.....	45
5. Estimated fish bypass efficiency at The Dalles Dam using concurrent sluiceway and spillway operation at various spilling rates.....	47
6. Total time sampled by week and corresponding number of juvenile salmonids caught, catch per hour and percentage catch rate for each species and major race sampled from April 26 through July 4, 1982 at The Dalles Dam.....	48
7. Total time sampled at each hour of daily fish trap operation and corresponding number of juvenile salmonids caught, catch per hour and percentage catch rate for each species and major race sampled from April 26 through July 4, 1982 at The Dalles Dam.....	49

ABSTRACT

The Dalles Dam (TDD) sluiceway was operated as a juvenile salmonid bypass system according to optimum criteria for 16 h/d, and bypassed salmonids were continually sampled using an airlift trap from April 26 through July 4, 1982. Fish marked and released upstream by the NMFS and other agencies were recovered to estimate travel time from point of release to TDD, but survival could not be estimated. The bypass efficiency of the sluiceway was estimated from marked fish releases and found to be related to percentage spill by an inverse exponential relationship ($r^2 = 0.96$). Maximum bypass efficiency was projected to be approximately 40% when no spilling occurs. Assuming a constant bypass efficiency with respect to fish passing the powerhouse, approximately 70% of juveniles passing the project were passed through spill (50%) or the sluiceway (20%) when a 20% spilling rate occurred. The effect of spilling on sluiceway fish bypass efficiency precludes use of the airlift trap for indexing. The mean descaling rates for subyearling chinook and for yearling coho salmon passing through the trap were 5.98% and 2.31%, respectively. High variation in the results of 72 h delayed mortality tests for these species prevented drawing conclusions regarding mortality to fish captured with the trap.

INTRODUCTION

Background

Juvenile anadromous salmonids produced in the Columbia River basin above Bonneville Dam must pass up to nine dams on their migration to the ocean (Fig. 1). Where there is no downstream migrant protection, fish pass these dams either route varies from year to year with the proportion of water spilled. Studies at main stem Columbia Dams have shown that downstream migrants passing through turbines suffer a much higher mortality than those using spillways (Schoeneman et al. 1961). As more Columbia River hydroelectric and storage projects have been completed in recent years, spilling of excess water has decreased, forcing higher percentages of the juvenile salmonids to pass through the turbines. Consequently, there is an increased need to develop techniques to safely pass juvenile salmonids around dams and avoid mortality to juveniles caused by turbines.

Oregon Department of Fish and Wildlife was involved in development and evaluation of The Dalles Dam ice-trash sluiceway as a juvenile salmonid bypass system in 1971 (Michimoto 1971) and from 1977 through 1981 (Nichols et al. 1978; Nichols 1979, 1980; and Nichols and Ransom, 1981, 1982). During this time period, a specialized trap for sampling fish in the sluiceway was developed and improved, criteria for optimum operation of the sluiceway as a bypass system were identified, the level of injury to juvenile salmonids bypassed through the sluiceway was assessed, and estimates of the fish bypass efficiency of the sluiceway were made.

Development of the specialized fish sampling trap provided a means of monitoring passage of juvenile salmonids through the sluiceways on a continuing basis because the injury rate of collected fish was comparatively low (Nichols and Ransom 1982). Currently, monitoring of juvenile salmonid outmigrations or "indexing" in the main stem Columbia River occurs at

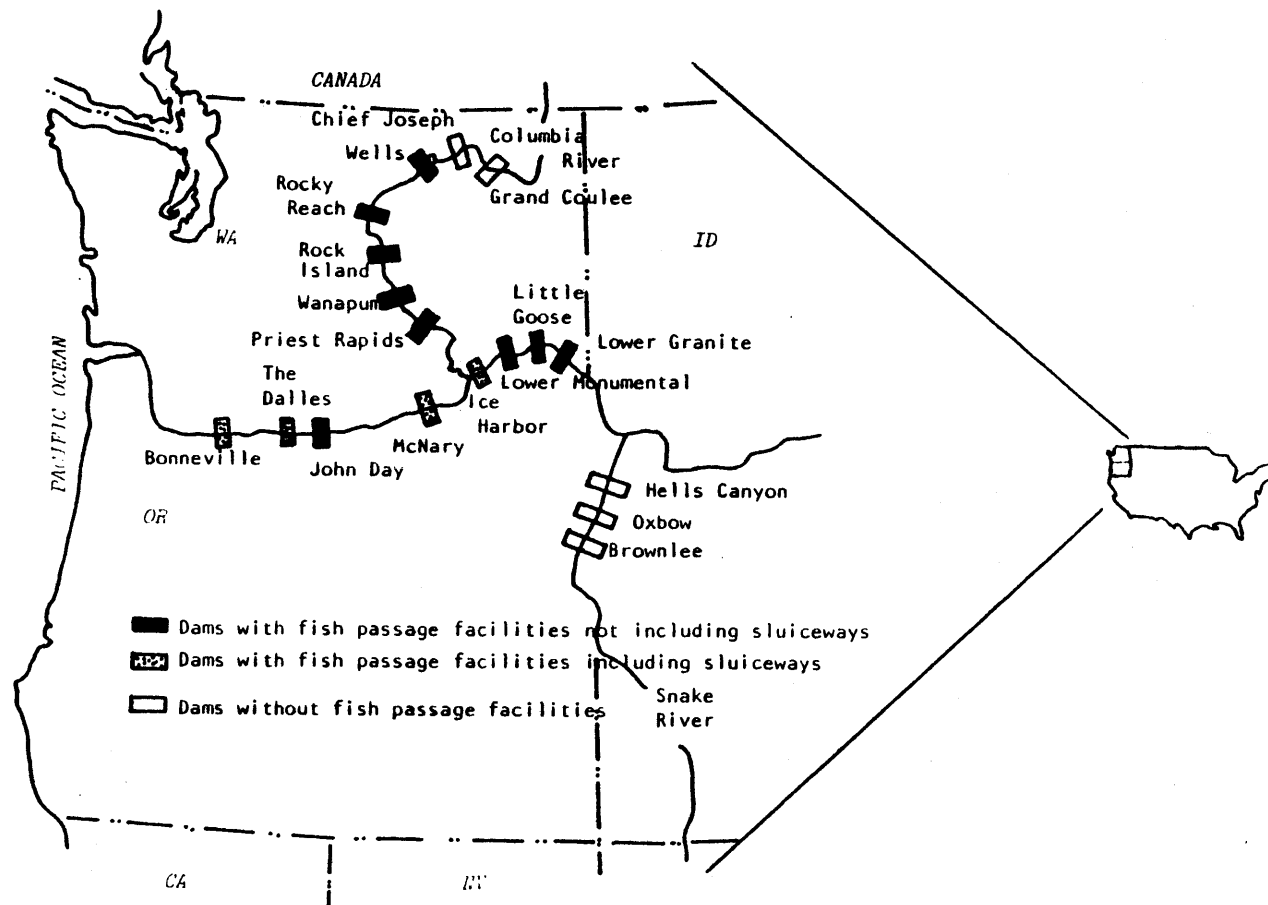


Fig. 1. Locations of dams affecting anadromous fish passage on the main-stem Columbia and Snake rivers.

McNary and John Day dams upstream of The Dalles Dam. Since these dams are adjacent, it would be advantageous to relocate indexing from John Day Dam further downstream.

Goals and Objectives

The goal of our research in 1982 was to evaluate the sluiceway fish trap for use as an indexing device, and to develop a sampling system to accurately estimate the timing and abundance of juvenile salmonids migrating past The Dalles Dam.

Our objectives were to:

1. Recover fish marked and released by the NMFS to estimate travel time and survival of juvenile salmonids from selected points between McNary and The Dalles dams.
2. Determine the bypass efficiency for juvenile salmonids through The Dalles Dam sluiceway.
3. Determine the effects of variation of season, river temperature, turbidity, powerhouse loading, nitrogen saturation, spill, fish size, and fish species on the proportion of emigrants captured in the fish trap.
4. Determine the rate of descaling and delayed mortality caused to fish captured by the fish trap.

METHODS

Sluiceway and Site Description

The Dalles Dam, located at river mile 191.5 (308.1 km) is unique among Columbia River dams in that its powerhouse is situated parallel with rather than perpendicular to river flow (Fig. 2). The sluiceway at The Dalles Dam is a large rectangular channel which extends along the forebay side of the powerhouse, immediately above the turbine intakes (penstocks) and adjacent to the gatewells (Fig. 3). We have described the physical characteristics and general function of the sluiceway in previous reports (Nichols and Ransom 1982).

Sluiceway Operation

During 1983, the sluiceway was operated as a juvenile salmonid bypass system according to optimum criteria throughout the outmigration period except for a 5 d period in May during which repairs and modifications to the sluiceway fish trap were made. Optimum criteria includes passing a flow of up to approximately 4,000 cfs (112 m³/s) through three adjacent sluice gates in turbine unit 1 from 0600 to 1100 daily.

We requested that the forebay be maintained at or above 158 ft (48.2 m) msl and that turbine unit 1 remain at full load from 0600 to 2200 daily. This provided an inflow of approximately 3,600 cfs (101 m³/s). Normally, the forebay surface fluctuates between elevation 155 ft and 160 ft (47.2 m to 48.8 m) msl.

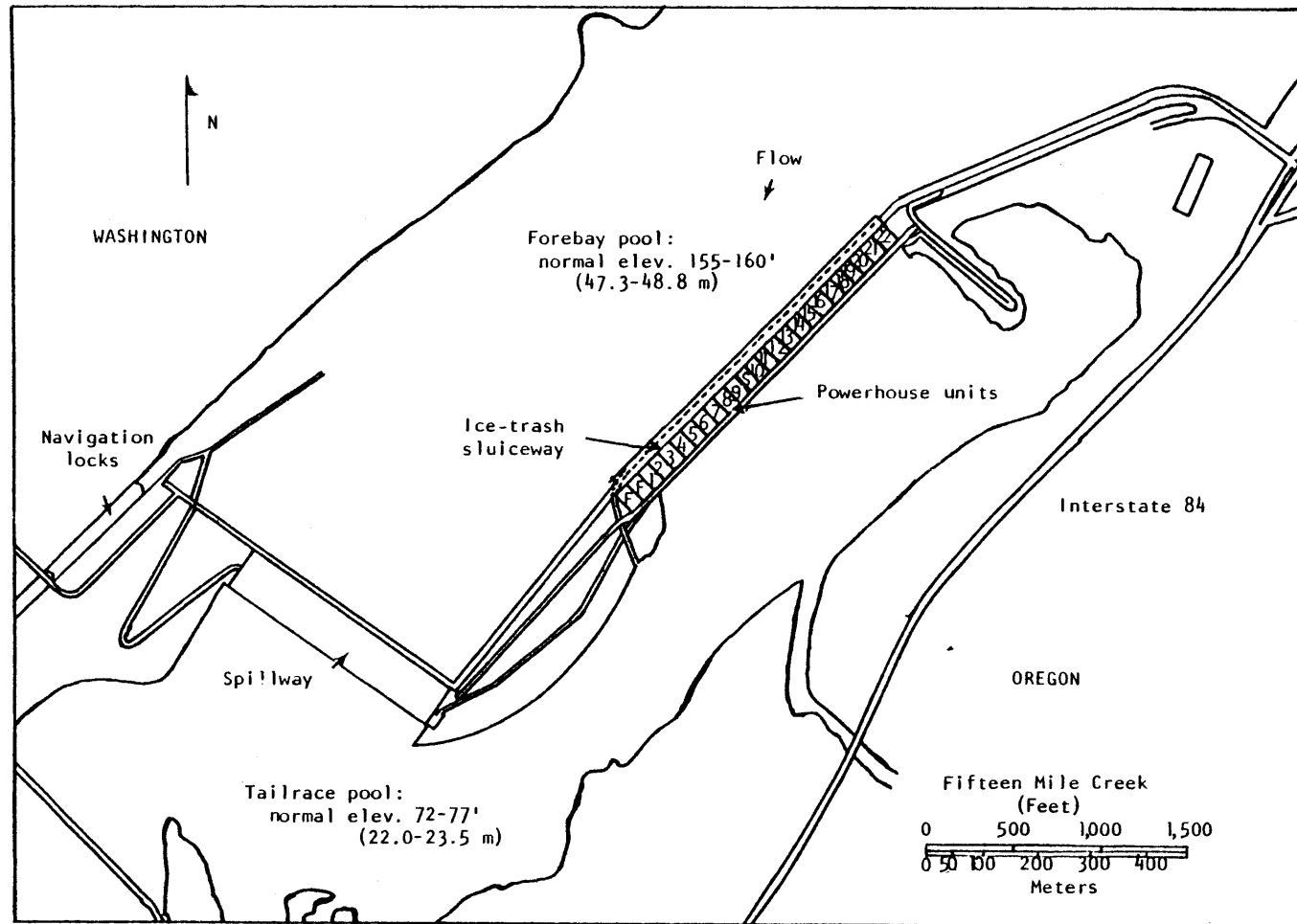


Fig. 2. Plan view of The Dalles Dam, Columbia River.

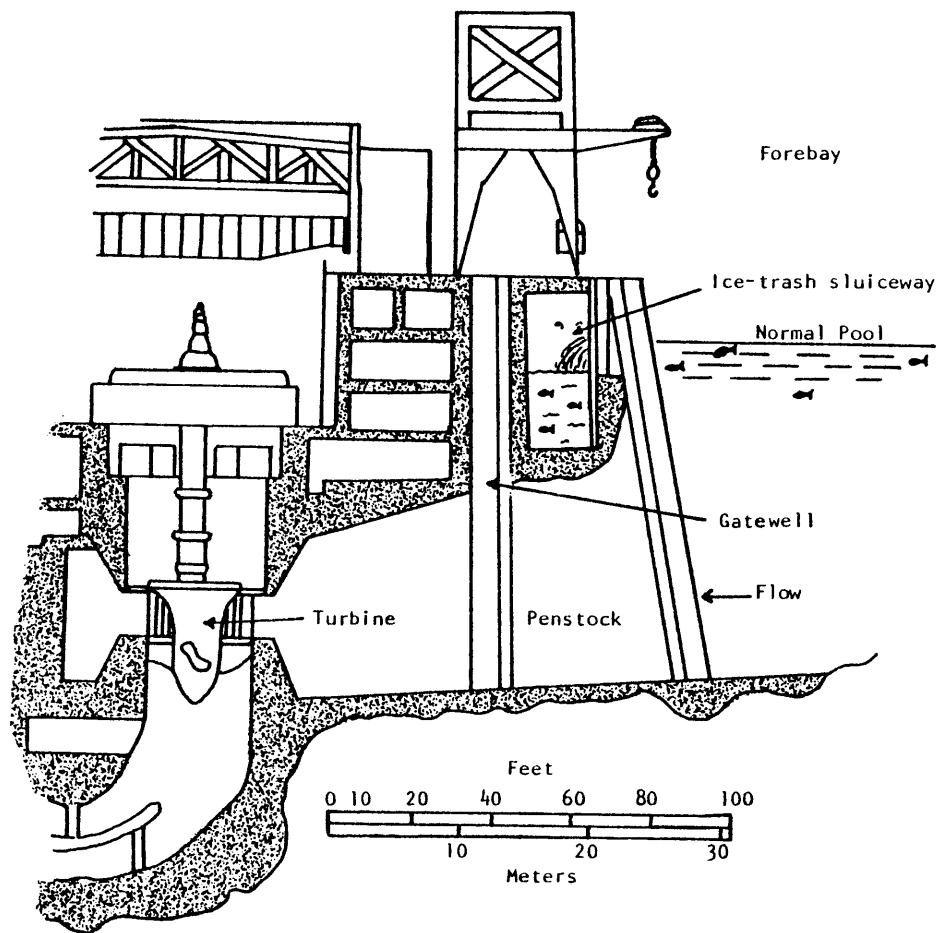


Fig. 3. Cross section of a Columbia River dam with a sluiceway.

We used the end gate located at the southwest end of the sluiceway to regulate water depth in and flow velocity through the sluiceway. This gate consists of two leaves positioned one above the other, which meet at elevation 148 ft (45.1 m). When closed together, they seal off the entire sluiceway effluent. Lowering the bottom gate or raising the upper gate will permit water to flow through the sluiceway when it is flooded from the forebay. During 1982, the upper end gate was lifted above the level of flow. The top of the lower end gate was situated 7 ft (2.1 m) (elevation 141 ft or 43.0 m msl) above the bottom of the sluiceway from April 26 through May 4. From May 5 through May 12, this end gate was lowered to elevation 137.5 ft (41.9 m) msl. It was then raised to 139.5 ft (42.5 m) msl where it remained for the duration of our sampling period (through July 4, 1982).

Description of Sluiceway Fish Trap

The fish trap (Fig. 4) was developed through modifications of earlier designs described by Nichols and Ransom (1982).

The opening was positioned in the sluiceway adjacent to the rear wall between elevations 141 and 144 ft (43.0 and 43.9 m) msl. The fish collecting unit was 68 ft (20.7 m) long and tapered from a 3 x 3 ft (91 x 91 cm) opening down to a 6 in (15.2 cm) diameter fitting at the downstream end. The sides of the collecting unit were constructed from panels of stainless steel wedge-wire screen (62% porosity). The rear fitting was attached to a rigid, specially fabricated plastic (PVC) pipe that turned upward and extended to a work platform where it was attached to a dewatering tank, or fish separator. Collected fish passed from the separator into a holding tank.

A trash rack was positioned approximately 10 ft (3 m) in front of the trap entrance to screen out large debris from water entering the trap. Another trash rack was located approximately 3 ft (1 m) in front of the fabricated pipe ascending to the work platform to protect it from sluiced debris.

When fish were not being sampled, a steel slide gate could be lowered to seal off the trap entrance.

A 16 x 3.5 ft (4.9 x 1.1 m) panel comprised of 62% porosity stainless steel wedge-wire screen was placed at the trap entrance prior to the 1982 season. The panel extended from the lower edge of the trap entrance and sloped downward. It was connected at its lower end to the front trash rack. Its function was to deflect fish upward into the trap entrance.

Following the first week in May, we added another deflection panel of the same material and dimension as that described above to the upper edge of the trap entrance. This panel sloped upward and connected to the front trash rack (Fig. 4).

An airlift pump operated by injecting 360 cfm (10.1 m³/min) of compressed air at 50 psi (3.5 kg/cm²) into the fabricated pipe extending from the fish collecting unit to the work platform. The air was injected at elevation 146 ft (44.5 m) msl, 12 ft (3.7 m) off the bottom of the sluiceway. During operation, this was approximately 6 ft (1.8 m) below the water surface, and lifted water and fish 11 ft (3.4 m) to the dewatering tank on the work platform.

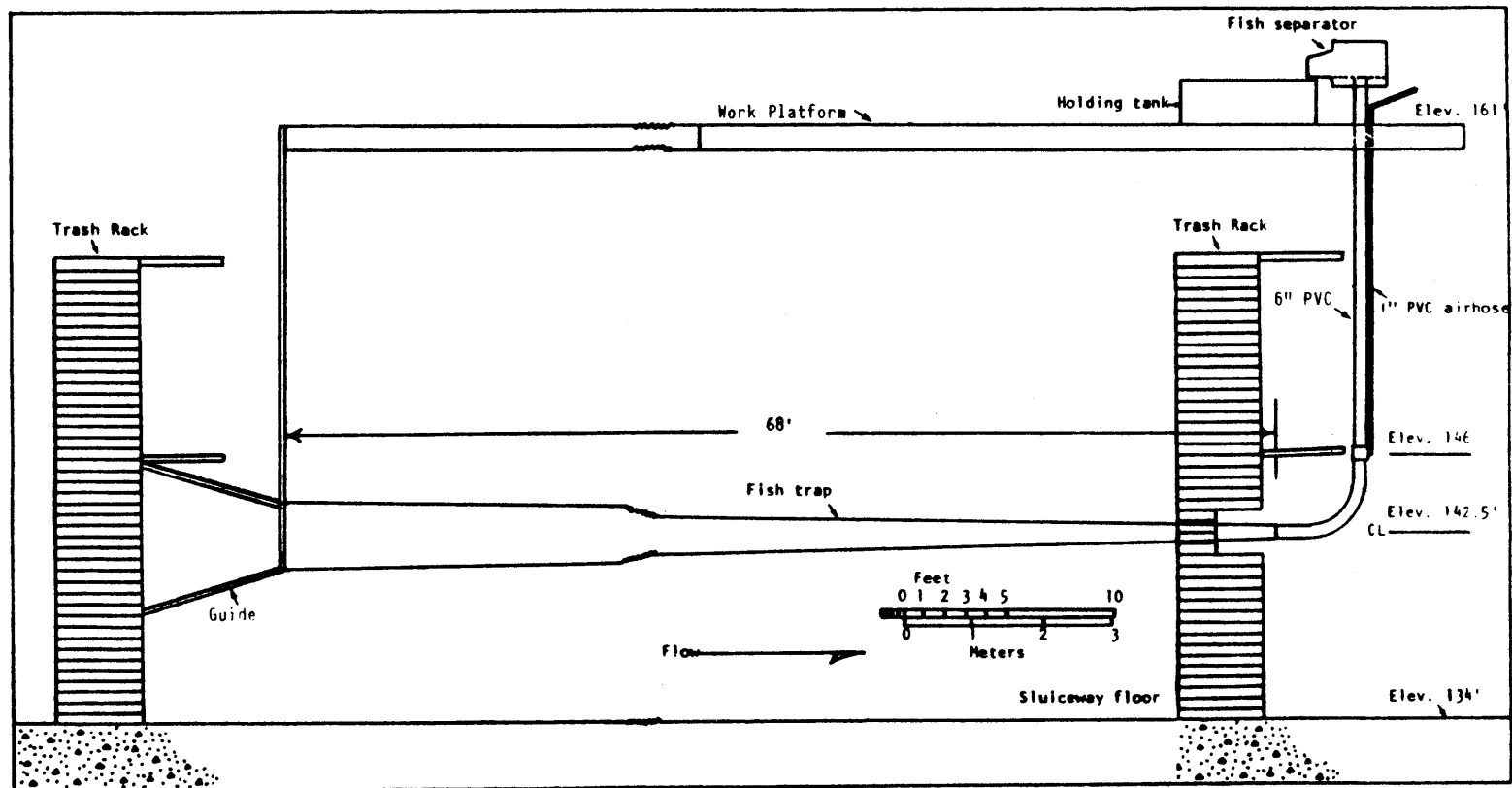


Fig. 4. Side view of the sluiceway fish trap and work platform at The Dalles Dam, 1982.

Fish entering the trap were lifted through the end pipe, flowed onto the perforated plate dewatering unit (fish separator), and dropped into a holding tank.

Objective 1.0. Recover fish marked and released by the NMFS to estimate travel time and survival of juvenile salmonids from selected points between McNary and The Dalles dams.

Task 1.1. Recover marked fish to enable determination of travel time and relative mortality between different release points.

The National Marine Fisheries Service (NMFS), under contract to the U.S. Army Corps of Engineers (USACE), released marked groups of juvenile steelhead trout, Salmo gairdneri, and yearling (spring) chinook salmon, Oncorhynchus tshawytscha, at various locations above The Dalles Dam during 1982 (Sims et al, 1983).

We sampled juvenile salmonids passing through the sluiceway from April 26 through July 4, 1982. Fish captured with the trap were removed from the holding tank and placed in a tank containing the anesthetic tricaine methanesulfonate (MS-222) to reduce handling stress. All juvenile salmonids collected were identified and enumerated hourly. All observed marks were recorded. Fish were examined for descaling and the fork length of a subsample of each species and major race was measured. The number of minutes during which the trap operated each hour was also recorded.

After the fish were processed, they were placed in a tank continuously supplied with fresh river water and were allowed to recover from the anesthetic before they were released into the sluiceway downstream of the fish trap.

Objective 2.0. Determine the bypass efficiency for juvenile salmonids through The Dalles Dam sluiceway.

Task 2.1. Determine the capture efficiency of the sluiceway fish trap relative to the number of juvenile salmonids passing through the sluiceway.

Capture efficiency of the sluiceway fish trap relative to the number of salmonids passing through the sluiceway was measured by releasing groups of marked hatchery coho (Oncorhynchus kisutch) into the sluiceway and recording the percentage of marked fish recovered in the trap.

Fifty test groups of approximately 500 hatchery coho salmon each were released into the sluiceway over a range of flows (2,500 to 4,600 cfs or 70 to 128 m³/s). Twenty-four tests preceded and 26 tests followed modification of the trap entrance by addition of a deflection panel to the upper side of the trap entrance.

Coho salmon smolts were provided by the Bonneville Hatchery (ODFW) and held in a 4 x 16 x 4 ft deep (1.2 x 4.9 x 1.2 m) tank on the upper work deck of the dam. Water from the forebay was passed through a denitrifying column and pumped through the tank continuously.

We dipnetted coho salmon smolts from the holding tank and placed them in buckets containing MS-222. We then counted them into a 100 gal (378.5 l) tank of fresh water mounted on a hand cart. The fish were then moved to the two release tubes at sluice gate 12, allowed to recover from the anesthetic, and released into the sluiceway.

Each release tube consisted of a lower section of rigid 6 in (15.2 cm) diameter PVC pipe attached to the sluice gate pier nose and an upper section of 6 in (15.2 cm) diameter flexible hose that was tied to the work deck railing at the upper end. One release tube allowed us to release fish approximately 5 ft (1.5 m) above and the other approximately 4 ft (1.2 m) below the water surface to determine if there was a resulting affect on recapture rates of released fish.

Prior to each release, we removed captured fish from the trap's holding tank. The trap was operated for approximately 10 minutes following each release to allow sufficient time for recapture of all fish entering the trap.

Task 2.2. Determine the capture efficiency of the trap relative to the number of juvenile salmonids passing The Dalles Dam.

Capture efficiency of the sluiceway fish trap relative to the number of juvenile salmonids passing The Dalles Dam was measured by releasing groups of marked juvenile chinook salmon and steelhead trout above The Dalles Dam and recording the percentage of marked fish recovered in the trap.

Nine groups of from 461 to 1,003 yearling (spring) chinook salmon and steelhead trout were collected at McNary Dam and marked with a cold brand and upper caudal fin clips by the NMFS, transported to below John Day Dam and released at various points and times of day into The Dalles Dam pool during May 1982 (Appendix 1).

It was then possible to estimate the fish bypass efficiency of the sluiceway by dividing the trap efficiency with respect to fish passing the project by the trap efficiency with respect to fish moving through the sluiceway as determined under Task 2.1.

Objective 3.0. Determine the effects of variation in season, river temperature, turbidity, powerhouse loading, nitrogen saturation, spill, fish size and fish species on the proportion of emigrants captured in the fish trap.

Task 3.1. Develop indexing efficiency curves for juvenile salmonids emigrating from April 15 through June 30.

Daily or hourly data covering our sampling periods and regarding river temperature, turbidity, nitrogen saturation level, powerhouse loading, spill and flow through the powerhouse was collected directly or obtained from

The Dalles Dam project. Pertinent or daily averages of these factors were then calculated for comparison by regression analysis with recapture rates of released groups of marked juvenile salmonids (Appendix 2).

- Objective 4.0. Determine the rate of descaling and delayed mortality caused to fish captured by the fish trap.
- Task 4.1. Determine the rate of descaling of fish captured by the trap.
- Task 4.2. Determine the rate of delayed mortality to salmonids captured by the trap.

Subyearling (fall) chinook salmon, Oncorhynchus tshawytscha, were collected with the sluiceway fish trap for use in conducting tests of descaling and mortality associated with capture by the trap. Hatchery coho salmon were also used for these tests. Tests of descaling and mortality were conducted simultaneously, but test results were analyzed separately. Test fish were held for 2 days before testing.

The fish were anesthetized with MS-222 and examined for descaling prior to testing. Each fish was examined and subjectively placed into one of the following categories: 0, <5, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50 or >50% descaled. Fish classified in the <5% category were assigned a value of 2.5% while those in the >50% category were assigned a value of 75% descaled for data analysis.

Fish with the least amount of descaling (generally <5%) were used for test releases while fish which were 5-10% descaled were used for control groups.

We recorded the extent of descaling of each fish in each test group and gave each fish a caudal fin clip. Control group fish were given a caudal fin clip on the opposite caudal fin lobe from that used to mark test groups fish. Caudal fin lobes used to mark test and control groups were alternated for consecutive test groups.

Groups of approximately 50 subyearling chinook salmon or coho salmon were released directly into the entrance of the trap during regular sluiceway operation. These fish were released through a release tube placed into the opening of the sluiceway fish trap, and the tube was subsequently flushed with several buckets of water.

Groups of approximately 50 control fish of the same species were placed directly into the sluiceway fish traps holding tank into which released fish moved after passing through the trap.

The mixed test and control groups were anesthetized with MS-222 following recapture and re-examined for descaling. The two groups were held together in fresh water for 72 h. The number of mortalities among test and control groups was recorded every 24 h.

The first two releases of subyearling chinook salmon were made using a flexible release tube. However, the flexible tube was replaced by a 20 ft (6.1 m) section of rigid 4 in (10.2 cm) diameter PVC pipe after we experienced inordinately high descaling and mortality rates among the first two test groups. The remaining nine test releases of subyearling chinook salmon and two test releases of coho salmon were made through the PVC release tube.

We made one additional release of subyearling chinook salmon directly onto the perforated wedge-wire screen of the trap's dewatering box (fish separator). Following this release, we modified the dewatering box by placing 0.5 in (1.27 cm) diameter PVC tubing over the perforated wedge-wire screen.

Adjusted (post-test less pre-test) mean percentage of body surface descaled per fish and adjusted (test group less control group divided by the mean number of fish in the two groups) 72 h mortality rate was determined for each test group.

RESULTS AND DISCUSSION

Objective 1.0. Recover fish marked and released by the NMFS to estimate travel time and survival of juvenile salmonids from selected points between McNary and The Dalles dams.

Task 1.1. Recover marked fish to enable determination of travel time and relative mortality between different release points.

We captured representatives of 86 marked groups of yearling (spring) chinook salmon and 53 marked groups of yearling steelhead trout between April 29 and June 3, 1982 (Appendices 4 and 5). Recoveries in The Dalles Dam sluiceway of these marked fish released upstream by the NMFS and other agencies could be used for estimating travel time of each marked group from the point of release to The Dalles Dam.

The number of fish in each marked group passing The Dalles Dam could not be accurately estimated because of the effects of spilling on sluiceway fish bypass efficiency as discussed under Objective 2. Therefore, survival from the point of release to The Dalles Dam could not be estimated.

We observed a peak in passage of yearling salmonids [steelhead trout; spring chinook, coho, and sockeye (*Oncorhynchus nerka*) salmon] through the sluiceway which presumably corresponded to a peak in migration past The Dalles Dam between May 10 and 30, 1982, and corresponded in general to a peak in spilling during May 17-23 (Figs. 5 through 8). During this spring peak in spilling, approximately 44% of the total flow past The Dalles Dam was discharged as spill.

We observed a peak in passage of subyearling (fall) chinook salmon through the sluiceway during the week of June 14-20 when, again, approximately 44% of the total flow past The Dalles Dam was passing as spill (Fig. 9). Spilling continued to increase through the end of our sampling period (July 4, 1982). Increased spilling resulted in reduced sluiceway

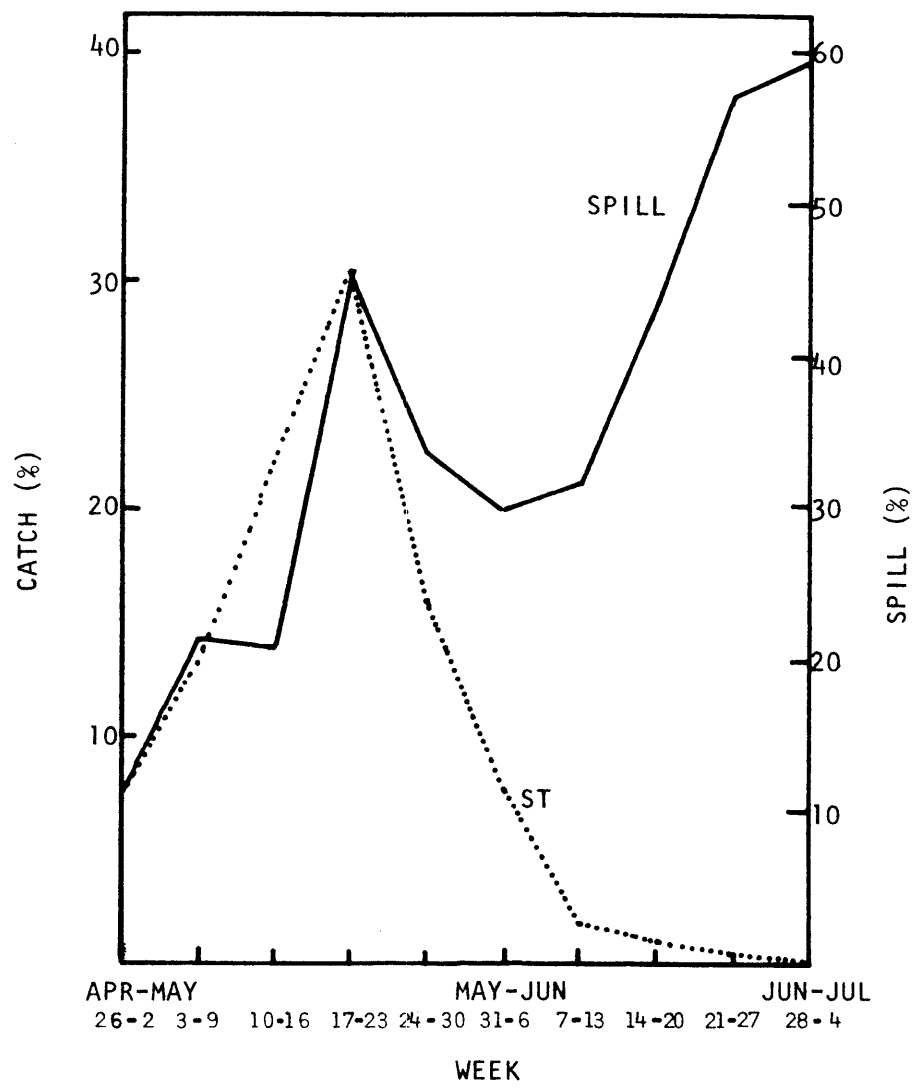


Fig. 5. Catch rate of steelhead trout (ST) and mean rate of spilling by week at The Dalles Dam from April 26 through July 4, 1982.

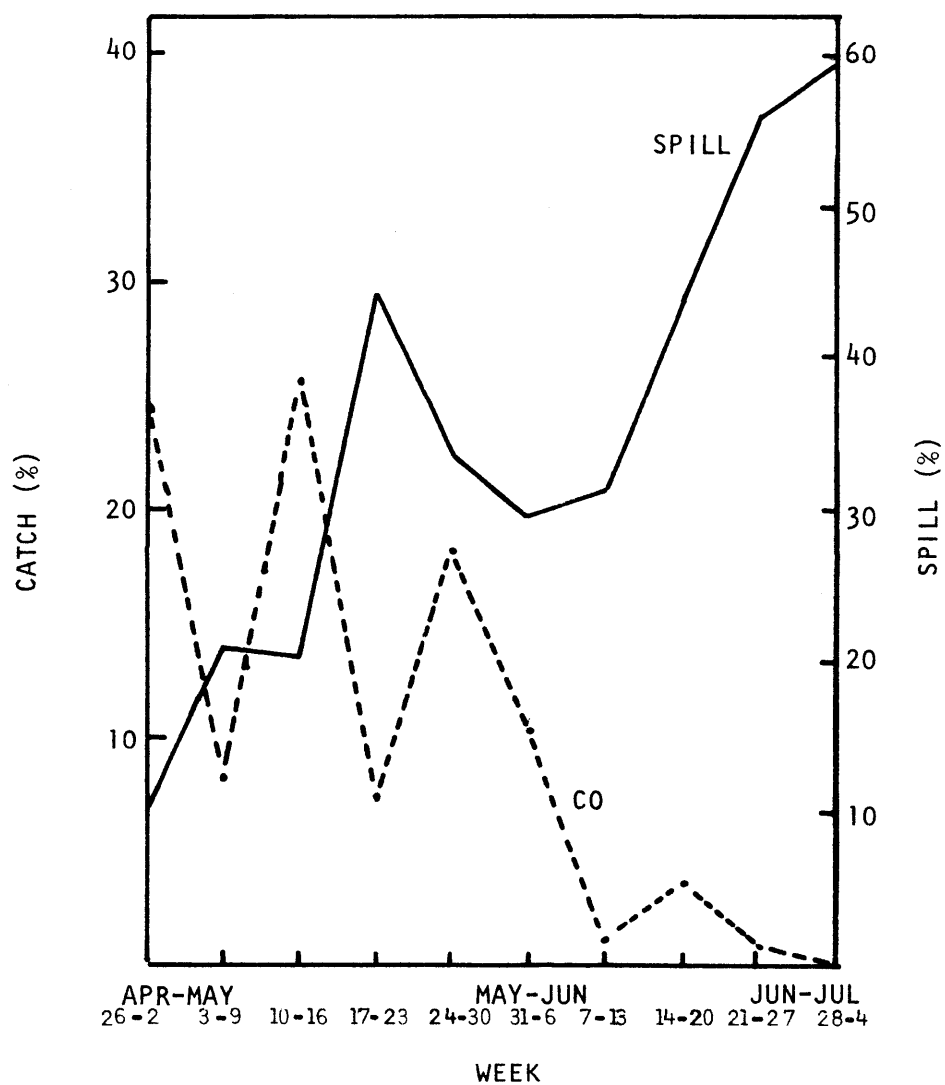


Fig. 6. Catch rate of coho salmon (CO) and mean rate of spilling by week at The Dalles Dam from April 26 through July 4, 1982.

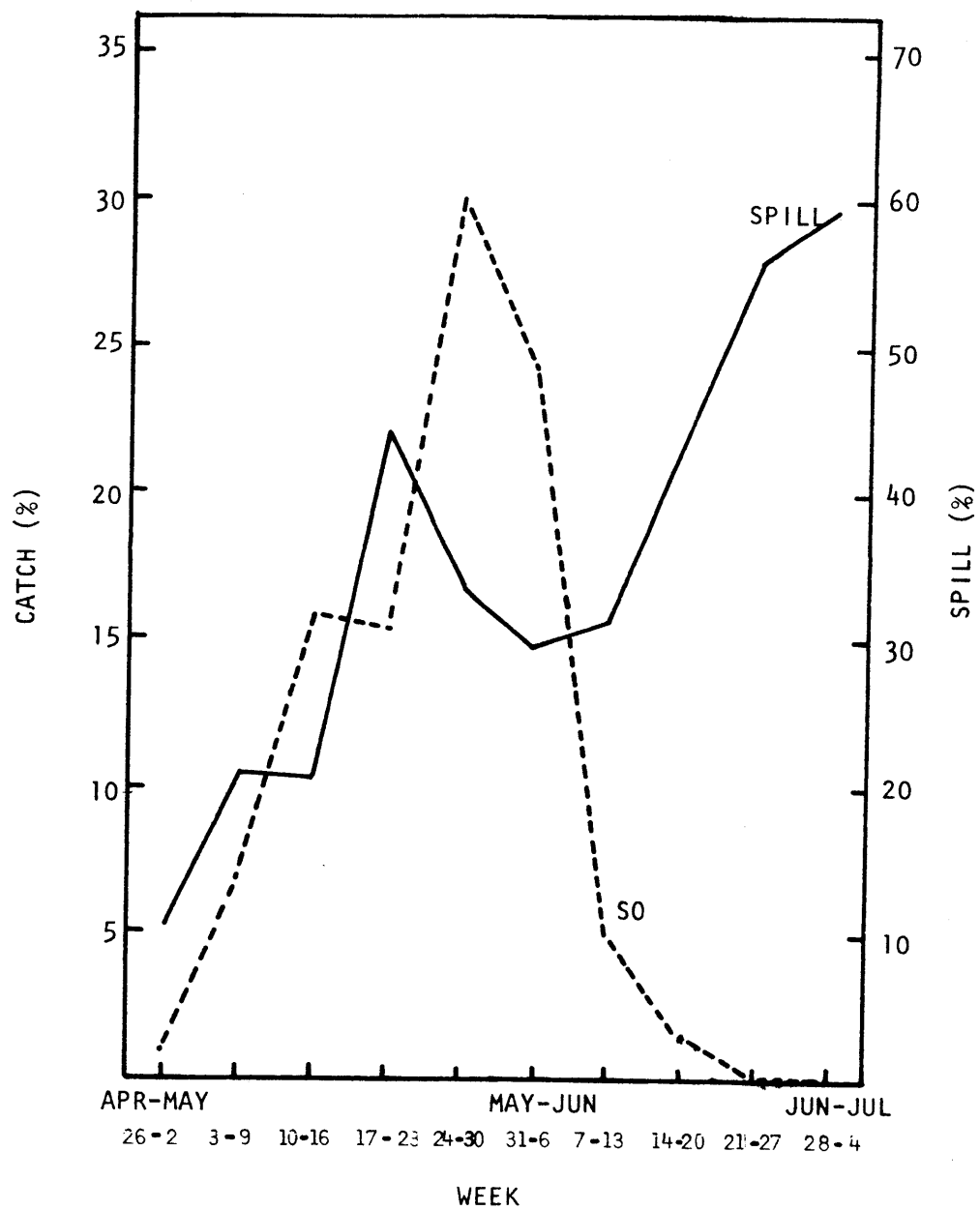


Fig. 7. Catch rate of sockeye salmon (S0) and mean rate of spilling by week at The Dalles Dam from April 26 through July 4, 1982.

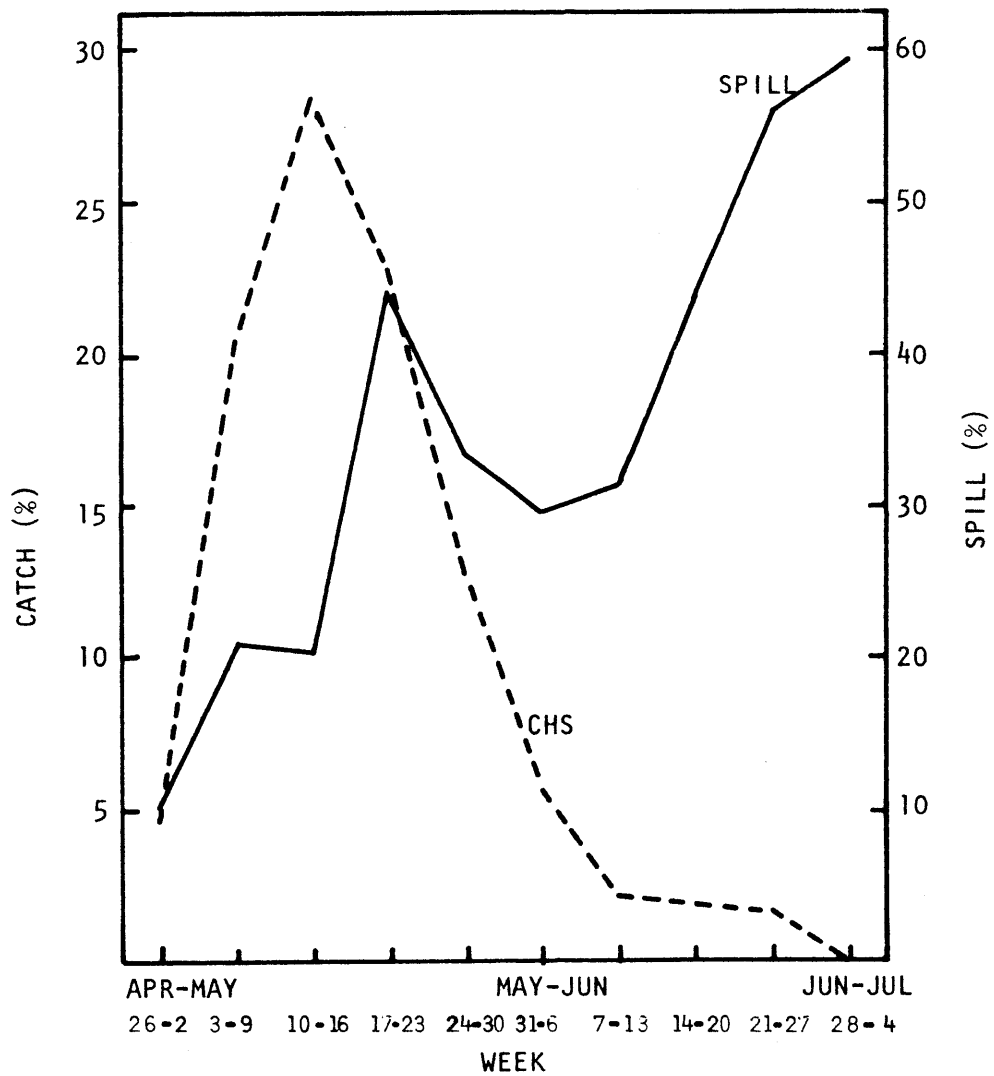


Fig. 8. Catch rate of yearling (spring) chinook salmon (CHS) and mean rate of spilling by week at The Dalles Dam from April 26 through July 4, 1982.

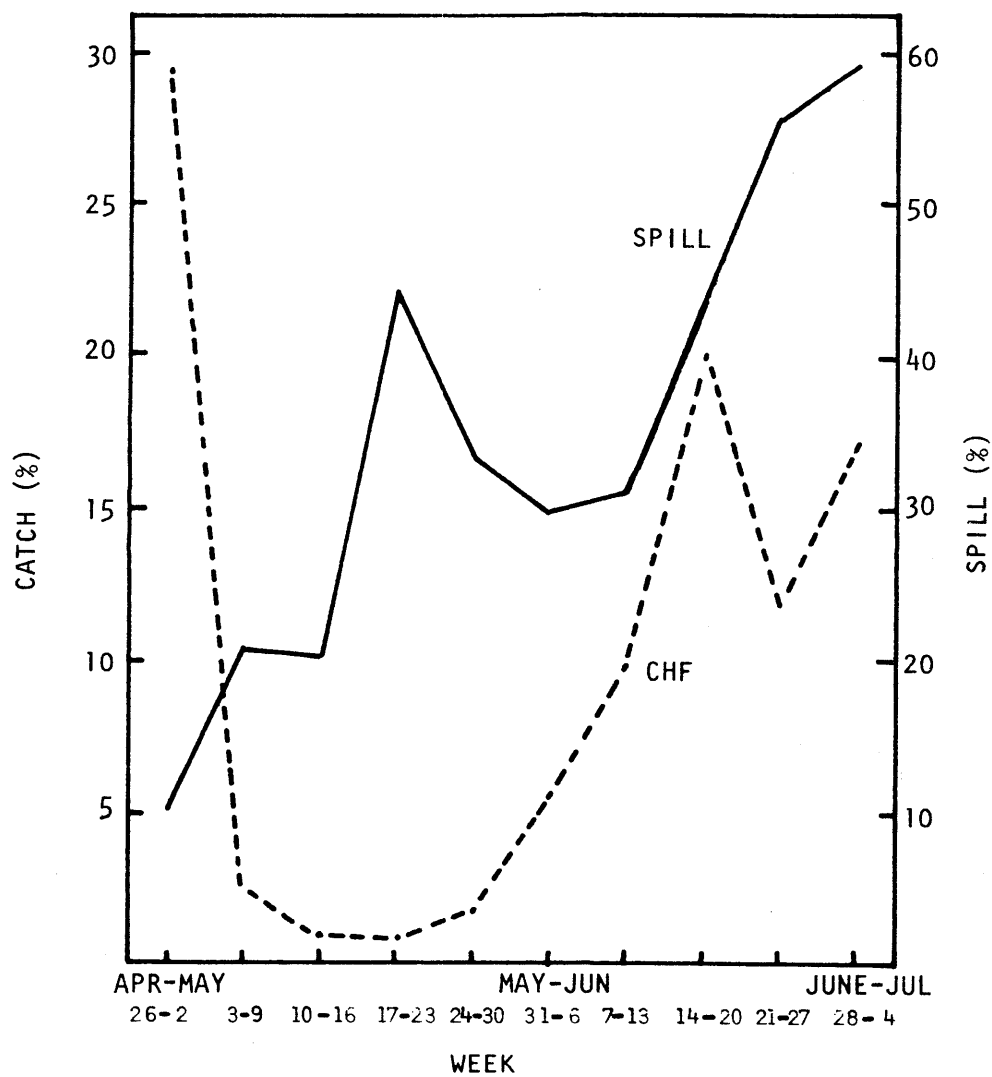


Fig. 9. Catch rate of subyearling (fall) chinook salmon (CHF) and mean rate of spilling by week at The Dalles Dam from April 26 through July 4, 1982.

fish bypass efficiency as discussed under Objective 2. Hence, indexing efficiency was also reduced. This must have masked a later peak in subyearling passage at The Dalles Dam because subyearling passage at John Day Dam as reported by the NMFS did not occur until the week of July 19 to 25, 1982 (NMFS, Rufus, OR, personal communication).

Diel passage patterns of juvenile salmonids through the sluiceway also appeared to be greatly affected by spilling in 1982. Passage peaked much earlier in the day (0600-1000) in 1982 (Figures 5-14) than in previous years (1200-1300) (Nichols and Ransom 1982). Correspondingly, spilling was reduced or halted during the hours of darkness (2200-0500) and increased through the day (0500-2200) in 1982. Fish could have accumulated in the forebay over night and passed through the sluiceway in the early morning prior to heavy spilling, but passage through the sluiceway may have decreased in response to increased spilling through the day.

Objective 2.0. Determine the bypass efficiency for juvenile salmonids through The Dalles Dam sluiceway.

Task 2.1. Determine the capture efficiency of the sluiceway fish trap relative to the number of juvenile salmonids passing through the sluiceway.

Results of releases of marked juvenile hatchery coho salmon into the sluiceway to estimate the capture efficiency of the sluiceway fish trap are presented in Tables 1 and 2. Capture efficiency was determined prior to and following addition of an upper deflection panel which was attached to the trap opening.

Regression analysis showed no significant relationship ($r^2 = 0.08$) between recapture rate of marked fish (percent recapture) and percentage of the cross-sectional area of the water column strained by the sluiceway fish trap (percent area strained) over the 50 tests and range of flows observed during these tests.

We also calculated regressions of percentage recapture on flow. No significant relationship was indicated before ($r^2 = 0.07$) or following ($r^2 = 0.01$) trap modification or when data groups were combined ($r^2 = 0.41$). Since there was no apparent relationship between flow through the sluiceway and trap capture efficiency over the range of flows observed, data from all tests were combined to determine the mean trap capture efficiencies before and after modification of the trap entrance.

Fish releases following trap modification were alternately made at the water surface and at a depth of approximately 4 ft (1.22 m). A group comparison (t) test indicated no significant difference ($P \leq 0.05$) in mean trap capture efficiency between the surface and submerged releases. Hence, data were combined to estimate overall capture efficiency of the trap following modification of the entrance.

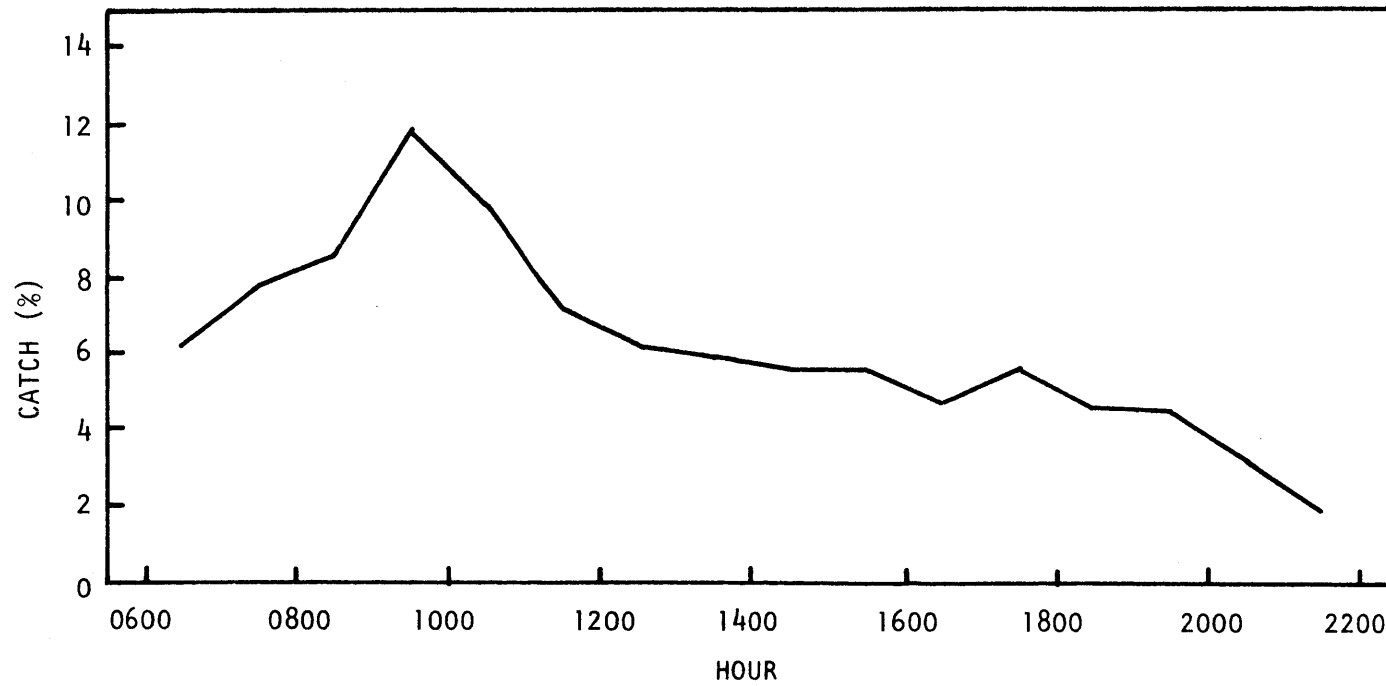


Fig. 10. Percent of total steelhead trout catch from April 26 through July 4, 1982 at The Dalles Dam occurring at each hour of sluiceway fish trap operation.

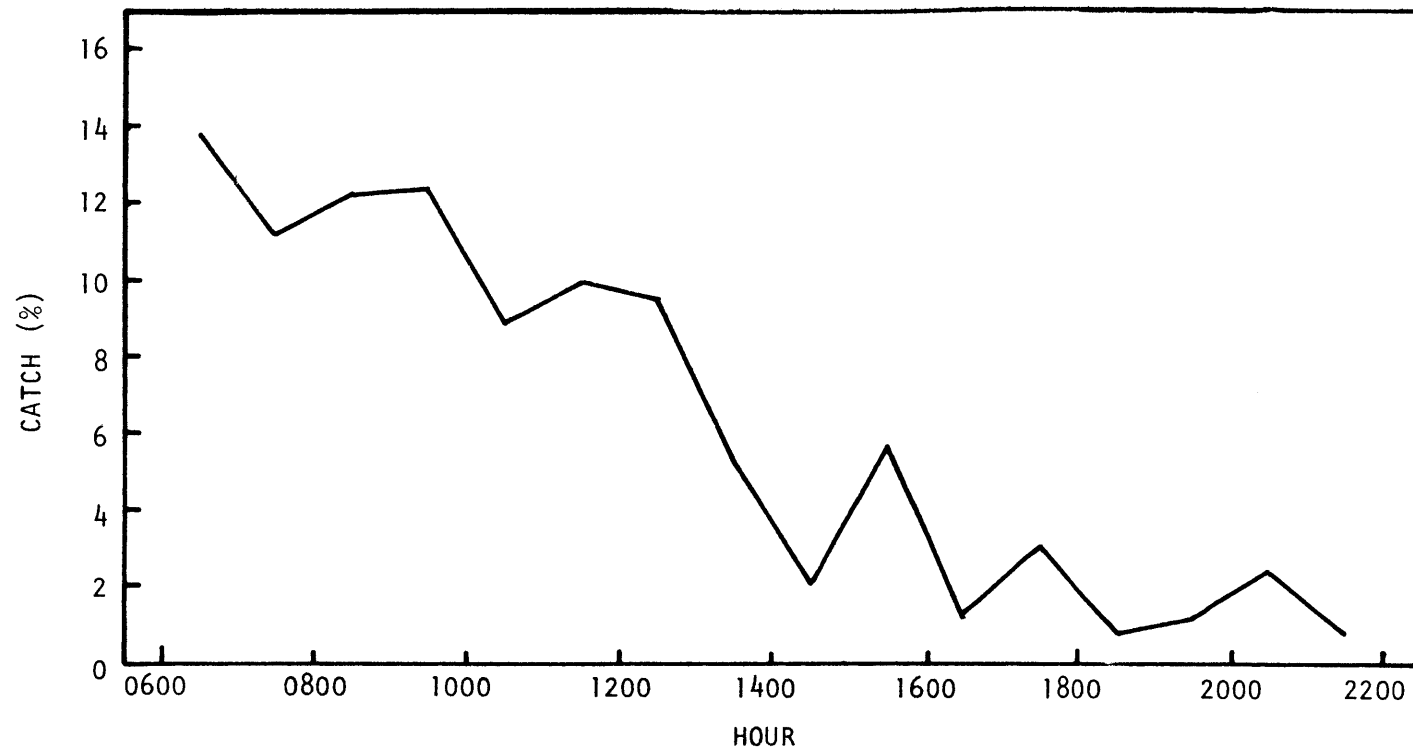


Fig. 11. Percent of total coho salmon catch from April 26 through July 4, 1982 at The Dalles Dam occurring at each hour of sluiceway fish trap operation.

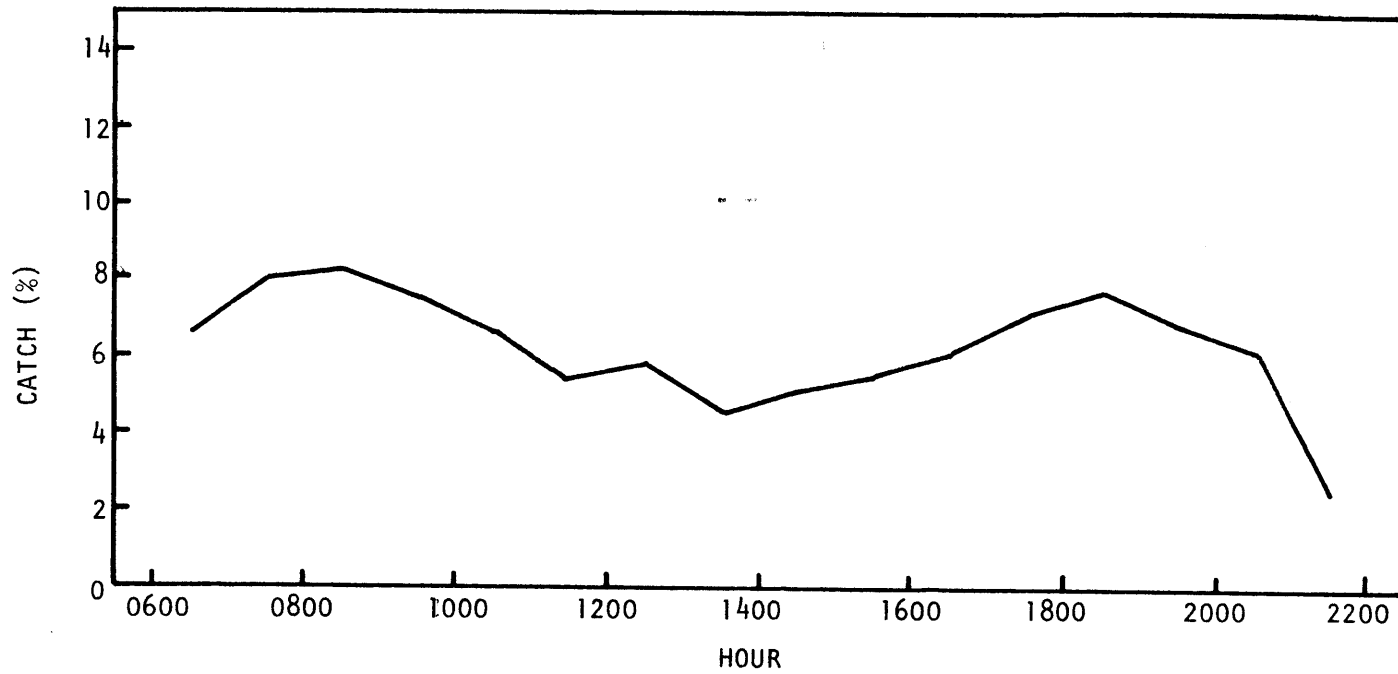


Fig. 12. Percent of total sockeye salmon catch from April 26 through July 4, 1982 at The Dalles Dam occurring at each hour of sluiceway fish trap operation.

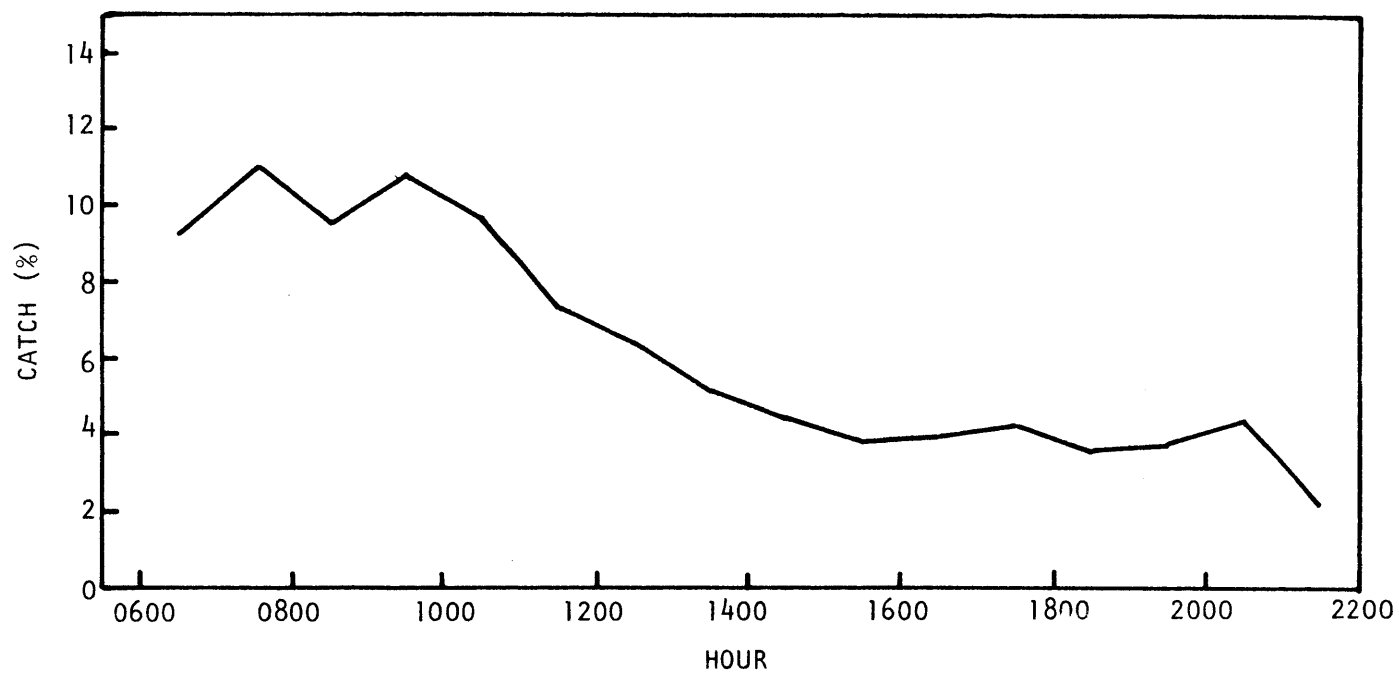


Fig. 13. Percentage of total yearling (spring) chinook salmon catch from April 26 through July 4, 1982 at The Dalles Dam occurring at each hour of sluiceway fish trap operation.

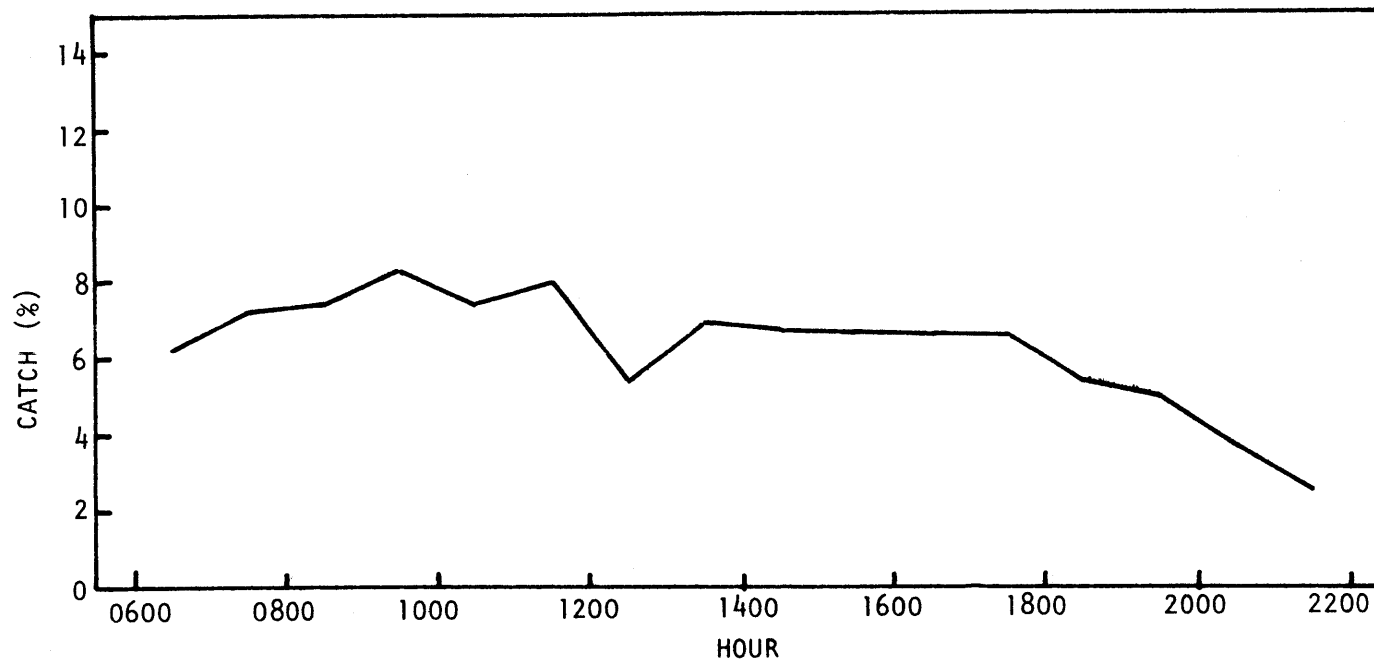


Fig. 14. Percentage of total subyearling (fall) chinook salmon catch from April 25 through July 4, 1982 at The Dalles Dam occurring at each hour of sluiceway fish trap operation.

Table 1. Recapture rate of hatchery coho salmon released into The Dalles Dam sluiceway before modification of the trap entrance, 1982.

Date	Time	No. fish released	No. fish recaptured	% recapture	Sluiceway water level (ft)	% X-sec area strained	Flow ^a (cfs)	Surface (+) or submerged (-) release ^b
4/30	1430	500	13	2.60	21.50	2.60	3,200	+
4/30	1530	500	8	1.60	21.75	2.51	3,300	+
4/30	1630	500	22	4.40	22.00	2.48	3,450	+
4/30	1730	500	14	2.80	22.00	2.48	3,450	+
4/30	1815	500	9	1.80	22.00	2.48	3,450	+
5/01	0715	516	6	1.16	21.00	2.54	3,100	+
5/01	0815	500	9	1.80	21.50	2.60	3,200	+
5/01	1115	495	20	4.04	19.00	2.87	2,850	+
5/03	0720	500	11	2.20	17.75	3.07	2,500	+
5/03	0800	500	6	1.20	18.75	2.91	2,750	+
5/03	0830	500	8	1.60	18.75	2.91	2,750	+
5/03	0900	502	8	1.59	19.00	2.87	2,850	+
5/03	1025	500	10	2.00	18.75	2.91	2,750	+
5/03	1100	500	13	2.60	18.00	3.03	2,600	+
5/03	1130	500	13	2.60	18.00	3.03	2,600	+
5/03	1205	500	10	2.00	18.00	3.03	2,600	+
5/03	1300	500	11	2.20	17.75	3.07	2,500	+
5/03	1345	500	7	1.40	18.75	2.91	2,750	+
5/05	1800	503	8	1.59	19.75 ^c	2.76	4,200 ^c	+
5/06	0800	500	9	1.80	17.50	3.12	2,700	+
5/06	0830	500	5	1.00	17.50	3.12	2,700	+
5/06	0855	500	9	1.80	18.00	3.03	3,000	+
5/13	1730	500	19	3.80	19.00 ^d	2.87	3,700 ^d	-
5/13	1745	500	16	3.20	19.00	2.87	3,700	-

^a Flows were estimated based upon forebay elevation, number of open sluiceways, relative sluiceway staff gauge readings, and sluiceway end gate elevation from flow relationships determined in 1980.

^b Submerged releases were made at a depth of 4 ft (1.22 m).

^c Sluiceway end gate was lowered from el. 141 ft (42.98 m) to el. 137.5 ft (41.91 m).

^d Sluiceway end gate was raised from el. 137.5 ft (41.91 m) to el. 139.5 ft (42.52 m).

Table 2. Recapture rate of hatchery coho salmon released into The Dalles Dam sluiceway after modification of the trap entrance, 1982.

Date	Time	No. fish released	No. fish recaptured	% recapture	Sluiceway water level (ft)	% X-sec area strained	Flow ^a (cfs)	Surface (+) or submerged (-) release ^b
5/27	1555	500	21	4.20	20.00	2.73	4,400	-
5/27	1610	500	19	3.80	19.75	2.76	4,200	+
5/27	1625	500	15	3.00	19.75	2.76	4,200	-
5/27	1650	500	19	3.80	19.75	2.76	4,200	+
5/27	1710	500	16	3.20	19.75	2.76	4,200	-
5/27	1727	500	16	3.20	19.50	2.80	4,000	+
5/27	1750	500	15	3.00	19.50	2.80	4,000	-
5/27	1805	500	28	5.60	19.50	2.80	4,000	+
5/27	1905	500	27	5.40	19.75	2.76	4,200	-
5/27	1920	500	15	3.00	19.75	2.76	4,200	+
5/27	1937	500	24	4.80	20.00	2.73	4,400	-
5/27	1956	500	12	2.40	20.00	2.73	4,400	+
5/27	2015	500	19	3.80	20.00	2.73	4,400	-
5/27	2032	500	24	4.80	20.25	2.69	4,500	+
5/27	2047	500	26	5.20	20.00	2.73	4,400	-
5/27	2104	500	16	3.20	20.00	2.73	4,400	+
5/28	0915	500	28	5.60	20.50	2.66	4,600	-
5/28	0930	500	17	3.40	20.50	2.66	4,600	+
5/28	0950	500	16	3.20	20.00	2.73	4,400	-
5/28	1000	500	18	3.60	20.25	2.69	4,500	+
5/28	1020	500	18	3.60	20.00	2.73	4,400	-
5/28	1040	500	17	3.40	20.00	2.73	4,400	+
5/28	1100	500	23	4.60	19.75	2.76	4,200	-
5/28	1130	500	23	4.60	19.75	2.80	4,000	+
5/28	1200	500	16	3.20	19.00	2.82	3,700	+
5/28	1220	500	21	3.20	19.50	2.80	4,000	-

^a Flows were estimated based upon forebay elevation, number of open sluiceways, relative sluiceway staff gauge readings, and sluiceway end gate elevation from flow relationships determined in 1980. End gate elevation was at 139.5 ft (42.52 m) throughout above tests.

^b Submerged releases were made at a depth of 4 ft (1.22 m).

A group comparison (t) test comparing the mean capture efficiencies of the trap before and after modification of the entrance indicated a significant ($P < 0.05$) improvement in capture efficiency following trap modification. The mean capture efficiency of the trap before modification was 2.22% (95% CI = $\pm 0.34\%$) and after modification was 3.92% (95% CI = $\pm 0.36\%$). The accuracy of the postmodification value is relatively high since the 95% confidence interval was within 9.31% of the mean.

Task 2.2. Determine the capture efficiency of the trap relative to the number of juvenile salmonids passing The Dalles Dam.

Results of the nine releases of yearling chinook salmon and steelhead trout into The Dalles Dam pool are presented in Table 3. We observed a strong inverse exponential relationship ($r^2 = 0.96$) between the percentage of total river flow discharged as spill and the resulting sluiceway fish bypass efficiency at The Dalles Dam (Fig. 15). Maximum bypass efficiency, therefore, occurs when there is no spilling. The sluiceway fish bypass efficiency corresponding to no spill was projected to be approximately 40% of the juvenile salmonids passing The Dalles Dam.

By assuming that the fish bypass efficiency of the sluiceway with respect to fish passing the powerhouse is a constant 40%, it is possible to estimate the proportion of total juvenile salmonids passing The Dalles Dam project through spill with changes in level of spilling.

We determined using regression analysis that the relationship between spilling rate (x) and sluiceway fish bypass efficiency (y) as represented in Fig. 15 was:

$$y = 40.60e^{-0.03x} \quad (1)$$

where e is the base of the system of natural logarithms.

If t is defined as being equal to the percentage of total fish passing the powerhouse which pass through the turbines, then $y + t$ is equal to the percentage of total fish passing the project which pass through the powerhouse. Since essentially all fish passing the project must pass either through the powerhouse or through spill, the percentage of total fish passing the project which pass through spill (S) must be:

$$S = 100\% - (y + t) \quad (2)$$

By assuming that 40% of all fish passing the powerhouse pass through the sluiceway and, hence, 60% pass through the turbines, we observe that:

$$\begin{aligned} \frac{t}{y} &= \frac{60\%}{40\%} \\ &= 1.5 \\ t &= 1.5y \end{aligned}$$

Table 3. Capture efficiency of the sluiceway fish trap with respect to fish passing The Dalles Dam powerhouse and efficiency of The Dalles Dam sluiceway for bypassing juvenile salmonids.

Release Date	No. Released	No. Recaptured	Proportion Recaptured	Trap Efficiency ^a	Sluiceway Fish Bypass Efficiency ^c	Mean Spill (%) ^d
5/06/82	982	8	0.008	0.0222 ^b	36.70	7.3
5/07/82	1,000	5	0.005	0.0222 ^b	22.52	12.8
5/08/82	1,003	8	0.008	0.0222 ^b	35.93	7.6
5/14/82	921	9	0.010	0.0392	24.93	16.5
5/15/82	936	6	0.006	0.0392	16.35	21.4
5/16/82	511	5	0.010	0.0392	24.96	9.3
5/20/82	461	1	0.002	0.0392	5.53	61.0
5/21/82	878	2	0.002	0.0392	5.81	52.2
5/22/82	987	8	0.008	0.0392	20.68	21.7

^a Refer to Task 2.1.

^b Releases made prior to trap entrance modification.

^c The proportion recaptured divided by the trap efficiency determined under Task 2.1.

^d The mean percentage of total river flow passing as spill from 1h before the first recapture to 1h following the last recapture from each release group. Time spans from 1h before to 1h after recaptures ranged from 3 to 15 h with a mean of 8.6 h.

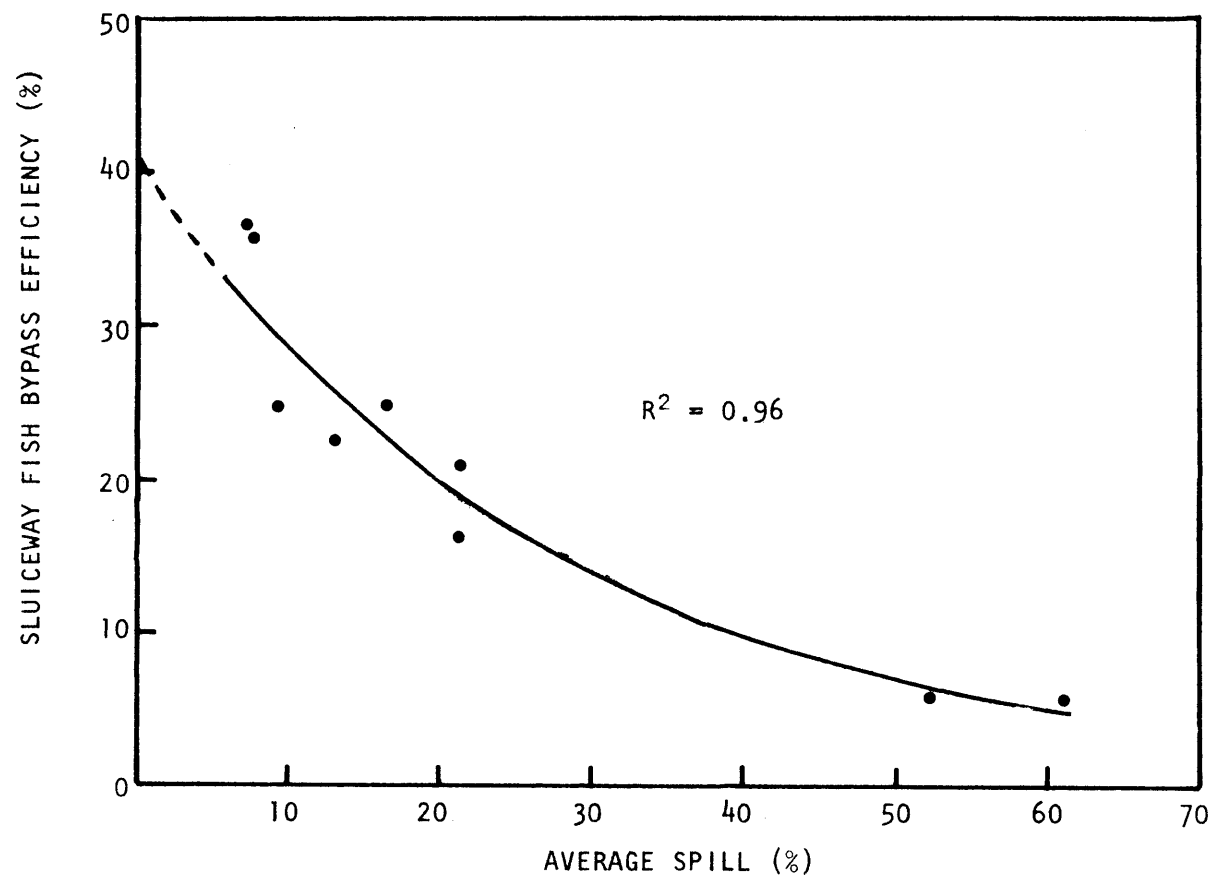


Fig. 15. Relationship between mean percentage of total river flow passing The Dalles Dam as spill and sluiceway fish bypass efficiency.

And, by substitution into equation (2):

$$\begin{aligned} S &= 100\% - (y + 1.5y) \\ &= 100\% - 2.5y \end{aligned} \tag{3}$$

Now, for any rate of spilling (x) equation (1) defines the resulting percentage of total fish passing the project which passes through the sluiceway (y), and equation (3) defines the resulting percentage which passes through spill (S), (Appendix 6). The resulting relationship between spilling rate and fish passing through spill (spillway fish bypass efficiency) is presented in Fig. 16.

By adding S and y, we can estimate the combined passage of fish through spill and the sluiceway (fish bypass efficiency) at various rates of spilling. This relationship is depicted in Fig. 17.

We estimated that approximately 70% of all juvenile salmonids passing the project were passed either through spill (50%) or through the sluiceway (20%) when the sluiceway was operated according to optimum criteria and 20% of the total flow past the project was discharged as spill.

Objective 3.0. Determine the effects of variation in season, river temperature, turbidity, powerhouse loading, nitrogen saturation, spill, fish size and fish species on the proportion of emigrants captured in the fish trap.

Task 3.1. Develop indexing efficiency curves for juvenile salmonids emigrating from April 15 through June 30.

The relationship between indexing efficiency (or sluiceway bypass efficiency) observed using the sluiceway fish trap and the percentage of flow passing The Dalles Dam project as spill was discussed above under Task 2.2.

There were no significant relationships ($P \leq 0.05$) between indexing efficiency and fluctuations in river temperature, turbidity, powerhouse loading or nitrogen saturation observed during our period of data collection.

Although we originally intended to sample later into the year, funding limitations prevented us from doing so. As a result, we were unable to investigate the effects of seasonal variation and size and species of fish on indexing efficiency of the sluiceway fish trap.

Objective 4.0. Determine the rate of descaling and delayed mortality caused to fish captured by the fish trap.

Task 4.1. Determine the rate of descaling of fish captured by the trap.

Descaling rates of fish passing through the trap varied with variation in the methods and conditions under which we introduced test fish into the trap.

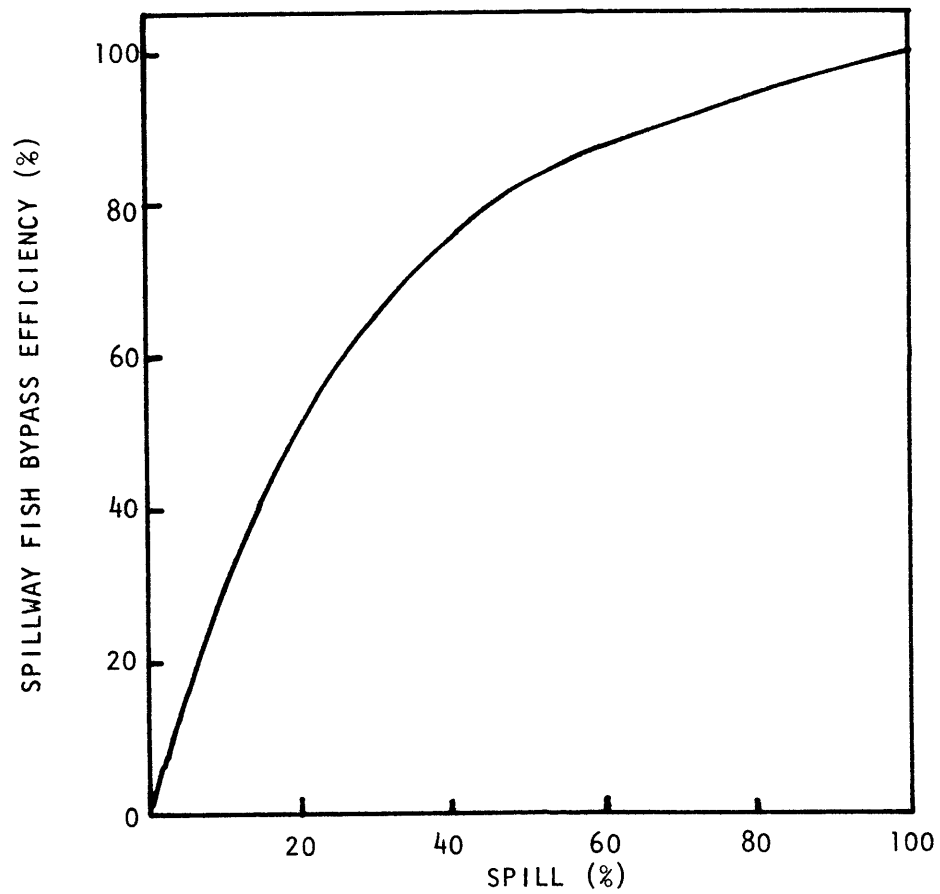


Fig. 16. Relationship between percentage of total river flow passing The Dalles Dam as spill and spillway fish bypass efficiency.

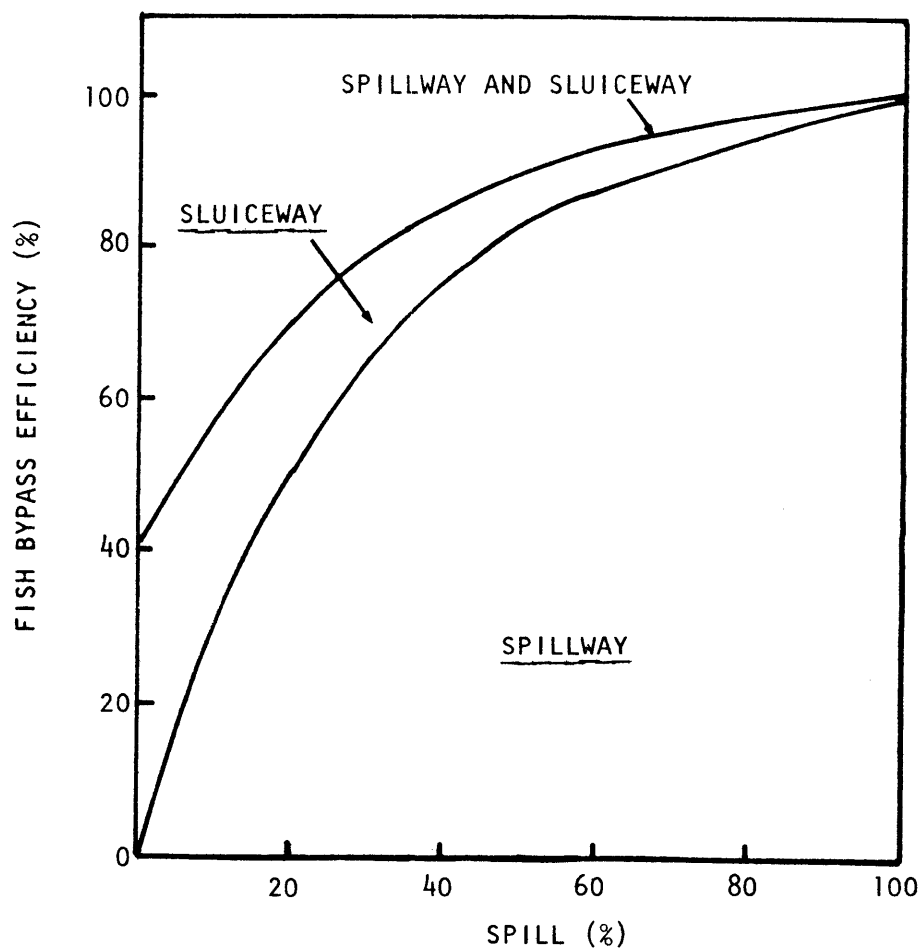


Fig. 17. Relationship between percentage of total river flow passing The Dalles Dam as spill and percentage of total outmigrating juvenile salmonids passing the project which pass either through spill or through the sluiceway (fish bypass efficiency) when both are operated.

The resulting adjusted (post-release less pre-release) mean descaling rate for the first two releases which were introduced using a flexible release tube was 13.26 (Table 4). The resulting adjusted mean descaling rate for the second two releases were made through a rigid 4.0 in (10.2 cm) diameter PVC pipe was 6.11%.

Many of the descaled fish we had observed during the above tests were descaled on only one side; possibly when sliding across the dewatering tank screen. We, therefore, released one group of fish directly onto the trap dewatering tank to determine if it was a major point of descaling. The resulting adjusted descaling rate was 6.88%.

As a result, we modified the dewatering tank by placing 0.5 in (1.3 cm) diameter PVC tubing above the perforated wedge-wire screen. The modification was adequate as a temporary measure, but would require further development if it were to be used for an extended period. The modified dewatering tank may have contributed to descaling during ensuing tests because it tended to trap debris, which was abundant during the testing period. The mean adjusted descaling rate for seven test releases following modification of the dewatering tank was 5.94%.

Bartlett's test for homogeneity of sample variances indicated that the variances among the three groups of mean descaling rates for subyearling (fall) chinook salmon in Table 4 were significantly different ($P \leq 0.05$). Therefore, we could not use analysis of variance to compare the means.

A chi-square test for homogeneity of binomial samples and the non-parametric Kruskal-Wallis H-test indicated that there was no significant difference ($P < 0.05$) in the central tendency of descaling rates for subyearling (fall) chinook salmon among the three sampling conditions when examined together. However, when examined separately using a modified group comparison (t) test that allows comparison of sample means with significantly different variances, we found that tests made using the flexible release tube resulted in a significantly ($P < 0.05$) higher descaling rate than tests using the PVC pipe either alone or in conjunction with the modified dewatering tank. While no difference in descaling rate was indicated between releases made through the PVC pipe before modification versus after modification of the dewatering tank, we feel that a significant improvement would have been realized following modification of the dewatering tank if the level of trash had been lower or if further modifications to handle heavy trash loads had been made to the dewatering tank.

The adjusted mean descaling rate for subyearling chinook salmon sampled with the sluiceway fish trap was 5.98% (95% CI = $\pm 1.14\%$) when data for nine releases made through the PVC release tube were combined.

The adjusted mean descaling rate for yearling hatchery coho salmon passing through the sluiceway fish trap as estimated from two test releases was 2.31% (95% CI = $\pm 0.86\%$). A group comparison (t) test indicated that the difference between the pre- and post-test descaling rates for coho salmon, though small, was significant ($P \leq 0.05$).

Table 4. Subyearling chinook and yearling coho salmon descaling rates from releases into the sluiceway fish trap.

Date	Number released	Number recaptured	Pre-release mean percentage descaling rate (%)	Pre-release s (%)	Post-release mean percentage descaling rate (%)	Post-release s (%)	Adjusted descaling rate (%)
<u>Subyearling Chinook Salmon ^a</u>							
<u>Releases performed with the flexible release tube</u>							
6/5/82	57	55	3.46	3.71	13.90	14.92	10.44
6/9/82	50	49	6.35	5.53	22.76	19.50	16.41
Combined (A)	107	104	4.81		17.98		13.26
<u>Releases performed with the PVC release tube</u>							
6/16/82	50	50	2.50	1.68	11.20	15.50	8.70
6/17/82	50	49	2.90	1.78	6.37	6.75	3.47
Combined (B)	100	99	2.70		8.81		6.11
<u>Releases performed with the PVC release tube and modified dewatering tank</u>							
6/19/82	50	49	2.70	1.66	4.69	3.87	1.99
6/19/82	49	49	1.86	1.57	4.46	5.20	2.60
6/23/82	50	48	1.90	1.08	10.98	14.40	9.08
6/25/82	50	50	2.20	1.70	11.30	18.54	9.10
6/26/82	51	50	2.60	2.68	7.95	12.63	5.35
6/29/82	50	49	2.50	1.73	11.68	15.54	9.18
6/29/82	50	49	2.65	1.96	6.94	7.81	4.29
Combined (C)	350	344	2.28		8.31		5.94
Combined (B+C)	450	443	2.42		8.40		5.98
<u>Single release into dewatering tank</u>							
6/17/82	49	48	2.96	1.81	9.79	11.58	6.88
<u>Yearling Coho Salmon ^b</u>							
<u>Releases performed with the PVC release tube and modified dewatering tank</u>							
6/9/82	50	50	10.20	6.30	13.50	8.03	3.30
6/26/82	50	50	12.00	2.45	13.31	4.70	1.31
Combined	100	100	11.10		13.41		2.31

^a Naturally migrating

^b Hatchery

Task 4.2.

Determine the rate of delayed mortality of salmonids captured by the trap.

Use of fish that were selected for low pre-test descaling rate may have biased the mortality test results. The mortality rate of a random sample of emigrating fish passing through the sluiceway fish trap may be higher than the rates reported here. Likewise, selection of fish with the least amount of descaling for test as opposed to control groups may be partially responsible for substantially higher mortality among control groups than test groups in some instances. However, regressions of post-test mortality on post-test descaling ($r^2 = 0.69$) and adjusted mortality on adjusted descaling ($r^2 = 0.27$) indicated only weak relationships. This suggests that the relationship between descaling and mortality is highly variable.

The adjusted 72 h mortality rate (test group less control group mortality divided by mean number of fish in test and control groups) of subyearling chinook salmon released through the flexible release tube was 21.15%. The adjusted 72 h mortality rate of those released through the PVC release tube before dewatering tank modifications was 9.33% while after dewatering tank modification the adjusted 72 h mortality rate was 5.27% (Table 5). The corresponding mean adjusted mortality rates (+95% CI) for these three data groups were 21.12% (+8.96%), 9.35% (+15.06%), and 5.31% (+6.20%), respectively.

Bartlett's test for homogeneity of sample variances indicated that there were significant differences ($P < 0.05$) among the variances associated with the mean adjusted mortality rates for each of the three groups of subyearling chinook salmon data in Table 5. Therefore, we could not use analysis of variance to compare these means.

A chi-square test for homogeneity of binomial samples indicated that there was a highly significant difference ($P < 0.01$) among the central tendencies of mortality rates for subyearling chinook salmon among the three data groups presented in Table 5. A modified group comparison (t) test and the non-parametric Mann-Whitney U-test were also used to compare the three groups of data. Results of both types of analysis were identical and paralleled results of analysis of the descaling data for these groups. There was a significant ($P < 0.05$) reduction in mortality when test fish were released through the PVC release tube as opposed to the flexible release tube, and there was no significant difference ($P < 0.05$) between tests made using the PVC release tube before or after modification of the dewatering tank.

The adjusted 72 h mortality rate for subyearling chinook salmon passing through the sluiceway fish trap was 6.16% when data for the nine releases made through the PVC release tube were combined. The corresponding mean adjusted mortality rate was 6.21% (95% CI = +4.69%). The confidence interval was only within 75.52% of the mean value indicating the relative inaccuracy of this estimate.

Table 5. Subyearling chinook and yearling coho salmon mortality rates from releases into the sluiceway fish trap.

Test Date	No. test group	No. control group	Total test group mortality	Total control group mortality	% test group mortality	% control group mortality	Adjusted mortality	Adjusted % mortality
<u>Subyearling Chinook Salmon ^a</u>								
<u>Releases performed with the flexible release tube</u>								
6/5/82	55	55	25	13	45.45	23.64	12	21.82
6/9/82	49	49	24	14	48.98	28.57	10	20.41
Combined (A)	<u>104</u>	<u>104</u>	<u>49</u>	<u>27</u>	<u>47.12</u>	<u>25.96</u>	<u>22</u>	<u>21.15</u>
<u>Releases performed with the PVC release tube</u>								
6/16/82	50	45	5	0	10.00	0.00	5	10.53
6/17/82	49	49	4	0	8.16	0.00	4	8.16
Combined (B)	<u>99</u>	<u>94</u>	<u>9</u>	<u>0</u>	<u>9.09</u>	<u>0.00</u>	<u>9</u>	<u>9.33</u>
<u>Releases performed with the PVC release tube and modified dewatering tank</u>								
6/19/82	49	45	5	0	10.64	0.00	5	10.87
6/19/82	49	47	1	5	2.04	10.64	0	0.00
6/23/82	48	49	13	6	27.08	12.24	7	14.43
6/25/82	50	47	5	8	10.00	17.02	0	0.00
6/26/82	50	51	8	2	16.00	3.92	6	11.88
6/29/82	49	50	7	14	14.29	28.00	0	0.00
6/29/82	49	50	3	8	6.12	16.00	0	0.00
Combined (C)	<u>344</u>	<u>339</u>	<u>42</u>	<u>43</u>	<u>12.21</u>	<u>12.68</u>	<u>18</u>	<u>5.27</u>
Combined (B+C)	443	433	51	43	11.51	9.93	27	6.16
<u>Yearling Coho Salmon ^b</u>								
<u>Releases formed with the PVC release tube and modified dewatering tank</u>								
6/9/82	50	54	1	0	2.00	0.00	1	1.92
6/26/82	50	50	0	0	0.00	0.00	0	0.00
Combined	<u>100</u>	<u>104</u>	<u>1</u>	<u>0</u>	<u>1.00</u>	<u>0.00</u>	<u>1</u>	<u>0.98</u>

^a Naturally migrating

^b Hatchery

The adjusted 72 h mortality rate for yearling hatchery coho salmon passing through the fish trap as estimated from two test releases was 0.98% (Table 5). The corresponding mean adjusted mortality rate was 0.96% (95% CI = $\pm 12.20\%$). Although the mortality rate of hatchery coho salmon passing through the sluiceway fish trap appears to be quite low, additional testing would be necessary to obtain a more accurate estimate of the true mortality rate.

CONCLUSIONS

1. Data from recoveries of marked fish collected with the sluiceway fish trap can be used to estimate travel time from the point of release to The Dalles Dam, but cannot be used to assess survival.
2. There is a strong inverse exponential relationship ($r^2 = 0.96$) between the percentage of total flow discharged as spill and the sluiceway fish bypass efficiency at The Dalles Dam. Maximum bypass efficiency occurs when there is no spill and was projected to be approximately 40% of the juvenile salmonids passing the project.
3. Assuming a constant fish bypass efficiency of 40% through the sluiceway, with respect to fish passing the powerhouse, we estimated that approximately 70% of all juvenile salmonids passing the project at any point in time were passed either through spill (50%) or through the sluiceway (20%) when the sluiceway was operated according to optimum criteria and 20% of the total flow past the project was discharged as spill.
4. The effect of spilling on the efficiency of the sluiceway as a bypass system precludes indexing at The Dalles Dam using the sluiceway fish trap.
5. The mean descaling rates of subyearling (fall) chinook and yearling coho salmon passing through the sluiceway fish trap were relatively low (5.98% and 2.31%, respectively). High variation in the results of 72 h delayed mortality tests for these species prevented drawing conclusions regarding mortality to fish captured with the trap.

RECOMMENDATIONS

1. The Dalles Dam should not be used as a location for indexing the outmigration of juvenile salmonids in the lower Columbia River because of the effect of spilling on the proportion of outmigrants passing the powerhouse.
2. The Dalles Dam sluiceway should be operated as a juvenile salmonid bypass system according to basic operating standards developed by ODFW in conjunction with the other fisheries agencies and the U.S. Army Corps of Engineers.

3. The spillway should be operated in conjunction with the sluiceway to affect an acceptable level of protection to juvenile salmonids during peak periods of outmigration. At least 20% of the instantaneous total flow past the project should be discharged as spill. In conjunction with sluiceway operation, this should bypass approximately 70% of the outmigrants.
4. Alternative juvenile salmonid bypass systems, including of a submersible traveling screen system, should be investigated.

ACKNOWLEDGEMENTS

The assistance of personnel with the Oregon Department of Fish and Wildlife, employees of the National Marine Fisheries Service at McNary Dam and staff of the U.S. Army Corps of Engineers are greatly acknowledged.

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APPENDICES

Appendix 1. Releases of branded fish into The Dalles Dam pool.

Release Date	Release Time	Species ^a	Number Released ^b	Number Recaptured	Brand ^c			Clip ^d	Release Site	Source
					Sym.	Loc.	Pos.			
5/6	20:50	ChS	982	8	+J	LA	1	UC	Biggs Ramp	McNary Dam
5/7	20:55	ChS	1,000	5	+J	LA	3	UC	Biggs Ramp	McNary Dam
5/8	13:30	ChS	1,003	8	+N	LA	1	UC	Horsethief Lake, WA	McNary Dam
5/14	21:00	ChS	921	9	+N	LA	3	UC	Biggs Grain Dock	McNary Dam
5/15	18:30	ChS	936	6	+T	LA	3	UC	John Day Dam Spill Bay 22	McNary Dam
5/16	18:30	ChS	511	5	+T	LA	1	UC	John Day Dam Spill Bay 22	McNary Dam
5/20	15:00	ChS	404	1	+J	RA	1	UC	Biggs Ramp	McNary Dam
		St	57	0						
		Total	461	1						
5/21	12:10	ChS	472	2	+N	RA	1	UC	John Day Dam Spill Bay 22	McNary Dam
		St	406	0						
		Total	878	2						
5/22	20:40	ChS	580	5	+T	RA	1	UC	John Day Dam Spill Bay 22	McNary Dam
		St	407	3						
		Total	987	8						

^a ChS = Yearling (Spring) Chinook Salmon. St = Steelhead Trout.

^b Size: ChS - 13/lb., St - 8/lb.

^c Location: LA = Left Anterior, RA = Right Anterior.

^d Clip: UC = Upper Caudal.

Appendix 2. Mean values of environmental parameters which occurred during recovery with The Dalles Dam sluiceway fish trap of yearling (spring) chinook salmon and steelhead trout released below John Day Dam, May 6-22, 1982.

Release Date	Power Load per Unit	Temp. (°F)	Turbidity (JTU)	Nitrogen Saturation (%)	Proportion Recaptured
5/06	78.60	52°	1.5	118.50	0.008
5/07	76.37	53°	1.4	115.97	0.005
5/08	63.89	52°	1.5	113.62	0.008
5/14	69.37	53°	1.6	117.50	0.010
5/15	73.41	53°	1.7	120.64	0.006
5/16	83.64	54°	2.0	121.22	0.010
5/20	55.10	54°	1.8	121.35	0.002
5/21	66.29	55°	1.8	120.99	0.002
5/22	76.09	55°	1.8	120.87	0.008

Appendix 3. Recoveries of marked yearling (spring) chinook salmon at The Dalles Dam, 1982.

Mark	Position	Location	^a Clip	^b Date	No. fish	Mark	Position	Location	^a Clip	^b Date	No. fish
B	4	RA	N	4/29	1	1K	3	LM	N	5/18	1
C	3	RA	N	5/1	1					5/22	2
E	1	RM	AD	5/19	1					5/23	1
				5/24	1					5/24	2
	Total				2		Total			5/25	1
										5/30	1
G	2	RA	UC	5/6	1	1L	3	LM	N	5/10	1
H	2	RA	UC	5/10	1					5/14	1
H	1	LA	UC	5/8	1					5/15	2
										5/16	1
H	1	LA	N	5/10	1					5/18	2
										5/19	1
H	1	RA	UC	5/15	1					5/23	5
HL	1	LM	N	5/23	1					5/24	4
										5/26	2
I	1	RA	UC	5/6	1					5/27	1
				5/11	1					5/28	1
	Total				2					5/30	1
							Total			6/2	1
I	1	RA	LC	5/11	1						23
+J	1	LA	UC	5/7	8	1L	1	LM	N	5/11	1
+J	3	LA	UC	5/8	5					5/12	5
										5/14	1
+J	1	RA	UC	5/21	1					5/17	1
										5/18	1
1J	3	LA	N	5/23	1					5/19	2
										5/22	1
1K	1	RM	N	5/15	1					5/23	3
										5/24	3
1K	3	RM	N	5/22	1					5/26	1
				5/23	1		Total			5/28	1
	Total				2						20
						1L	3	LA	N	5/16	1
1K	1	LM	N	5/16	2	+N	1	RM	UC	5/22	2
				5/17	2	+N	3	LA	UC	5/15	9
				5/18	1	+N	1	LA	UC	5/8	8
				5/20	1	1N	1	LM	N	5/15	1
				5/22	1					5/21	1
				5/23	1					5/23	1
				5/28	1					6/3	1
	Total				9		Total				24

Appendix 3. (Cont'd)

Mark	Position	Location	<i>a</i> Clip	<i>b</i> Date	No. fish	Mark	Position	Location	<i>a</i> Clip	<i>b</i> Date	No. fish
IN	3	LM	N	5/18	1					5/27	1
				5/20	1					5/30	1
				5/21	1					6/2	1
				5/22	1					6/3	2
				5/25	1		Total				20
				5/27	1						
	Total			5/28	1	IV	3	LM	N	5/18	1
					7					5/22	1
1P	3	LM	N	5/22	3					5/23	4
										5/25	4
										5/26	2
										6/1	2
R	1	LM	N	6/1	1		Total				14
						IV	1	RM	N	5/23	3
										5/26	1
RI	1	LM	N	5/23	1		Total				4
1R	1	RM	N	5/20	1	IV	3	RM	N	5/26	3
				5/22	1						
	Total				2	X	2	RM	Y	5/5	1
1R	1	LM	N	5/23	1	1X	1	RM	N	5/12	1
				5/25	2					5/14	1
				5/29	2		Total				2
	Total				5	1X	1	LM	N	5/22	1
1R	3	LM	N	5/23	1					5/23	1
				5/24	1					5/24	1
				5/25	2					5/29	1
				5/28	1					5/30	1
				5/30	2		Total				5
				6/1	2	1X	3	LM	N	5/21	1
	Total				9					5/23	3
+T	3	LA	UC	5/16	6					5/24	1
										5/25	1
										5/26	1
+T	1	RA	UC	5/23	5					5/28	1
							Total				8
1U	1	RM	AD	5/18	1	1Y	3	LM	N	5/11	1
V	3	LM	N	5/23	1					5/14	1
										5/18	2
										5/22	1
IV	1	LM	N	5/16	1					5/23	1
				5/19	1					5/26	3
				5/22	1					5/27	1
				5/23	6					5/29	2
				5/24	1		Total				12
				5/25	5						

Appendix 3. (Cont'd)

Mark	Position	Location	α	Clip b	Date	No. fish	Mark	Position	Location	α	Clip b	Date	No. fish
IY	1	LM	N		5/13	2							
					5/14	4							
					5/15	4						5/11	3
					5/17	2		Total					6
					5/18	3							
					5/20	1	1 Δ	1	RA	UC		5/25	1
					5/22	2							
					5/23	1	1 Δ	3	RA	UC		5/17	1
					5/26	1							
					5/28	1	+1	1	LA	UC		5/9	3
					5/30	1						5/10	1
	Total					22						5/14	1
								Total					4
1Y	3	RM	N		5/18	1							
1Y	1	RM	N		5/27	1	+1	3	RA	UC		5/17	1
					6/1	1							
	Total					2	+1	3	LM	UC		5/23	1
1Z	1	LM	N		5/16	1							
					5/18	4	+1	1	LM	UC		5/25	1
					5/21	2							
					5/23	6	3	3	LA	UC		5/7	1
					5/24	3							
					5/25	5	3	2	LA	UC		5/8	1
					6/1	1						5/9	1
	Total					22		Total					2
1Z	1	RM	N		5/29	1	3	2	RA	N		5/8	1
1Z	2	LM	N		5/19	1	3	3	RA	UC		5/14	1
												5/15	2
1Z	3	LM	N		5/23	3						5/16	4
												5/17	1
1Z	3	LM	N		5/21	1		Total					8
					5/24	3							
					5/25	1	3	4	LA	UC		5/15	1
					5/28	1							
					5/30	1	3	4	RA	UC		5/16	1
					6/2	2						5/17	2
	Total					9		Total					3
1	2	LA	N		5/5	1	3	2	LM	UC		5/22	2
1	1	LM	N		5/25	1	3	4	LM	UC		5/23	2
												5/24	1
1 Δ	1	LA	UC		5/8	1		Total					3
1 Δ	3	LA	UC		5/9	2	3	3	LM	UC		5/24	1
					5/10	1							
							3	1	RM	N		5/27	1

Appendix 3. (Cont'd)

Mark	Position	Location ^a	Clip ^b	Date	No. fish	Mark	Position	Location ^a	Clip ^b	Date	No. fish
4	1	RM	N	5/15	1	II	1	LM	N	5/10	1
5	2	RA	Y	5/3	1		Total			5/15	2
5	3	RA	N	5/4	1	III	1	RA	N	5/7	1
				5/9	2						
	Total			5/13	1	I	2	LA	UC	5/9	1
5	1	RA	N	5/5	2	I	1	RA	UC	5/15	2
				5/6	2					5/16	1
				5/8	1					5/17	1
				5/9	1		Total				4
				5/12	1						
	Total			5/21	1	I	2	RA	UC	5/17	1
					8						
5	4	RA	N	5/11	1	I	4	RA	UC	5/22	1
				5/16	1						
	Total				2	I	4	LM	UC	5/20	1
5	1	LA	N	5/16	1						
						I	2	LM	UC	5/24	1
5	2	RM	N	5/20	1		Total			5/27	1
				6/2	1						2
	Total				2	I	4	RM	UC	5/29	1

^a Location Key: LA - Left Anterior
LM - Left Middle (Posterior)
RA - Right Anterior
RM - Right Middle (Posterior)

^b Clip Key: A - Adipose Fin
LC - Lower Caudal Fin
N - None
UC - Upper Caudal Fin
Y - Yes (fin unidentified)

Appendix 4. Recoveries of marked yearling steelhead trout at The Dalles Dam, 1982.

Mark	Position	Location	^a Clip	^b Date	No. fish	Mark	Position	Location	^a Clip	^b Date	No. fish
C	3	LM	N	5/22	1	1S	1	RA	N	5/5	1
F	1	RA	N	5/8	1					5/6	1
F	2	RA	N	5/14	3					5/14	1
F	3	RA	N	5/21	1					5/24	1
F	3	LA	N	5/25	1		Total				4
H	1	LA	UC	5/8	1	1S	1	LP	UC	5/30	1
I	1	LA	N	5/4	2	T	4	RA	N	5/8	1
I	1	RA	UC	5/10	1	+T	1	RA	UC	5/23	3
+J	3	LA	UC	5/8	1	U	1	LM	N	5/15	1
						VI	3	LM	UC	5/23	1
						IV	1	RA	N	5/7	1
+J	4	LA	AD	5/22	1					5/8	1
										5/17	1
1J	3	LA	N	5/22	3		Total				3
				5/23	1	IV	1	RA	AD	5/19	1
Total					4	1 Δ	3	LA	UC	5/9	1
1J	3	LA	AD	5/22	2	1 Δ	1	RA	UC	5/15	1
K	2	LA	N	5/14	1	1 Δ	1	LM	UC	5/23	1
1K	1	RA	AD	5/22	1	+1	3	LA	UC	5/6	1
R1	1	RA	N	5/1	1	+1	1	LA	UC	5/9	1
				5/3	1	+1	3	LM	UC	5/23	1
				5/4	1	2	1	RA	N	5/6	3
				5/9	1					5/8	5
				5/13	1					5/13	1
				5/16	1					5/16	1
Total					6		Total				10
1R	1	RA	N	5/13	1	2	2	RA	N	5/13	2
				5/16	1					5/16	1
Total					2					5/17	1
1R	1	RM	N	5/16	1		Total				4
1S	1	LA	?	5/5	1						
1S	1	LA	N	5/5	1	2	2	RA	N	5/15	1
1S	4	RA	N	5/25	3					5/16	1
										5/17	1
							Total				3

Appendix 4. (Cont'd)

Mark	Position	Location ^a	Clip ^b	Date	No. fish	Mark	Position	Location ^a	Clip ^b	Date	No. fish
2	2	LA	N	5/15	1						
2	3	RA	N	5/22	1						
				5/25	1						
	Total				2						
2	4	LA	N	5/25	1						
2	4	RA	N	6/3	1						
3	1	RA	UC	5/10	1						
3	1	RA	N	5/10	1						
3	3	RA	UC	5/15	1						
				5/17	1						
	Total				2						
3	3	LM	UC	5/22	1						
5	2	LA	UC	5/12	1						
5	2	RM	N	6/2	1						
LC	3	RA	UC	5/10	1						
LC	4	LM	UC	5/20	1						
15	2	RA	UC	5/11	1						
15	3	RA	UC	5/12	1						
				5/18	1						
	Total				2						
15	1	RA	UC	5/12	1						
15	3	LA	UC	5/18	1						

^a Location Key: LA - Left Anterior
LM - Left Middle (Posterior)
RA - Right Anterior
RM - Right Middle (Posterior)

^b Clip Key: A - Adipose Fin
LC - Lower Caudal Fin
N - None
UC - Upper Caudal Fin
Y - Yes (fin unidentified)

Appendix 5. Estimated fish bypass efficiency at The Dalles Dam using concurrent sluiceway and spillway operation at various spilling rates.

Spill (%) <i>a</i>	Fish Bypass Efficiency (%)		Total
	Sluiceway <i>b</i>	Spillway <i>c</i>	
0	41	0	41
5	34	15	49
10	29	28	57
15	24	40	64
20	20	50	70
25	17	58	75
30	14	65	79
35	12	70	82
40	10	75	85
45	8	80	88
50	7	82	89
55	6	85	91
60	5	88	93
65	4	90	94
70	4	90	94
75	3	92	95
80	2	95	97
85	2	95	97
90	2	95	97
95	1	98	99
100	0	100	100

a Percent of total river flow passing The Dalles Dam which passes as spill (x).

b Estimated percentage of total juvenile salmonids passing The Dalles Dam which pass through the sluiceway (y). $y = 40.60e(-0.03x)$.

c Estimated percentages of total juvenile salmonids passing The Dalles Dam which pass through spill (S). $S = 100\% - 2.5y$.

Appendix 6. Total time sampled by week and corresponding number of juvenile salmonids caught, catch per hour and percentge catch rate for each species and major race sampled from April 26 through July 4, 1982 at The Dalles Dam.

Week	Year (Spring) Chinook				Sub.-Yr. (Fall) Chinook				Steelhead			Coho			Sockeye		
	Minutes Fished	No. Caught	Catch/ Hour	%	No. Caught	Catch/ Hour	%	No. Caught	Catch/ Hour	%	No. Caught	Catch/ Hour	%	No. Caught	Catch/ Hour	%	
Apr 26- May 2	1,557	111	4.28	4.74	830	31.98	29.28	101	3.89	7.11	23	0.89	24.90	15	0.58	1.00	
May 3-9	4,365	1,338	18.39	20.40	206	2.83	2.59	527	7.24	13.24	21	0.29	8.11	286	3.93	6.80	
10-16	4,868	2,060	25.39	28.17	89	1.10	1.00	995	12.26	22.41	74	0.91	25.63	745	9.18	15.88	
17-23	6,452	2,183	20.30	22.52	105	0.98	0.89	1,784	16.59	30.31	28	0.26	7.32	959	8.92	15.42	
24-30	5,650	1,088	11.55	12.82	182	1.93	1.77	827	8.78	16.05	61	0.65	18.20	1,632	17.33	29.97	
May 31- Jun 6	4,967	411	4.96	5.51	503	6.08	5.56	347	4.19	7.66	30	0.36	10.18	1,159	14.00	24.21	
Jun 7-13	3,670	123	2.01	2.23	654	10.69	9.79	59	0.96	1.76	1	0.04	1.23	182	2.98	5.14	
14-20	4,807	136	1.70	1.88	1,759	21.96	20.10	45	0.56	1.03	10	0.12	3.51	69	0.86	1.49	
21-27	5,497	136	1.48	1.65	1,178	12.86	11.77	22	0.24	0.44	3	0.03	0.92	5	0.05	0.09	
Jun 28- Jul 4	1,580	2	0.08	0.08	496	18.84	17.24	0	0	0	0	0	0	0	0	0	
Total	43,413	7,588	90.15	100.00	6,002	109.24	100.00	4,707	54.73	100.00	251	3.56	100.00	5,052	57.83	100.00	

Appendix 7. Total time sampled at each hour of daily fish trap operation and corresponding number of juvenile salmonids caught, catch per hour and percentage catch rate for each species and major race sampled from April 26 through July 4, 1982, at The Dalles Dam.

Hour	Year (Spring) Chinook				Sub.-Yr. (Fall) Chinook				Steelhead			Coho			Sockeye		
	Minutes Fished	No. Caught	Catch/ Hour	%	No. Caught	Catch/ Hour	%	No. Caught	Catch/ Hour	%	No. Caught	Catch/ Hour	%	No. Caught	Catch/ Hour	%	
0600-0700	2,544	652	15.38	9.26	350	8.25	6.22	271	6.39	6.18	32	0.75	13.77	314	7.41	6.65	
0700-0800	2,932	893	18.27	11.01	464	9.50	7.16	396	8.10	7.84	30	0.61	11.20	436	8.92	8.01	
0800-0900	2,954	780	15.88	9.55	480	9.75	7.35	437	8.88	8.58	33	0.67	12.23	449	9.12	8.19	
0900-1000	2,768	831	18.01	10.85	507	10.99	8.28	564	12.23	11.82	31	0.67	12.26	389	8.43	7.57	
1000-1100	2,833	757	16.03	9.66	466	9.87	7.44	486	10.29	9.95	23	0.49	8.89	352	7.45	6.69	
1100-1200	2,760	567	12.33	7.43	487	10.59	7.98	343	7.46	7.21	25	0.54	9.92	279	6.07	5.45	
1200-1300	2,755	490	10.67	6.43	331	7.29	5.43	301	6.56	6.34	24	0.52	9.54	296	6.45	5.79	
1300-1400	2,590	376	8.71	5.25	393	9.10	6.86	267	6.19	5.98	12	0.28	5.07	219	5.07	4.55	
1400-1500	2,672	334	7.50	4.52	396	8.89	6.70	260	5.84	5.65	5	0.11	2.05	252	5.66	5.08	
1500-1600	2,525	271	6.44	3.88	373	8.86	6.68	246	5.85	5.65	13	0.31	5.64	258	6.13	5.50	
1600-1700	2,497	273	6.56	3.95	362	8.70	6.55	208	5.00	4.83	3	0.07	1.32	283	6.80	6.11	

Appendix 7. (Cont'd)

Hour	Year (Spring) Chinook				Sub.-Yr. (Fall) Chinook				Steelhead			Coho			Sockeye		
	Minutes Fished	No. Caught	Catch/ Hour	%	No. Caught	Catch/ Hour	%		No. Caught	Catch/ Hour	%	No. Caught	Catch/ Hour	%	No. Caught	Catch/ Hour	%
1700- 1800	2,597	308	7.12	4.29	379	8.76	6.60		253	5.85	5.65	7	0.16	2.95	346	7.99	7.18
1800- 1900	2,663	267	6.02	3.62	320	7.21	5.43		213	4.80	4.64	2	0.05	0.82	380	8.56	7.69
1900- 2000	2,772	288	6.23	3.76	306	6.62	4.99		217	4.70	4.54	3	0.06	1.18	353	7.64	6.86
2000- 2100	2,752	331	7.22	4.35	226	4.93	3.71		154	3.36	3.25	6	0.13	2.39	315	6.87	6.17
2100- 2200	2,799	170	3.64	2.20	162	3.47	2.62		91	1.95	1.89	2	0.04	0.78	131	2.81	2.52
Total	43,413	7,588	165.97	100.00	6,002	132.90	100.00		4,707	103.42	100.00	251	5.48	100.00	5,052	111.38	100.00